THE ENGINEERING RECORD

Published Weekly by the

McGraw Publishing Company

James H. McGraw, Pres.; Curtis E. Whittlesey, Sec. and Treas.

MAIN OFFICES:
239 West 39th Street, New York.

BRANCH OFFICES:
Chicago: Old Colony Building.
Philadelphia: Real Estate Trust Building.
Cleveland: Schofield Building.
San Francisco: Atlas Building.
London Office: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.

United States, Cuba and Mexico	$3.00 a year
Canada	$4.50 a year
Foreign subscription	$6.00 a year

25 shillings. 25 marks. 31 francs.

Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of The Engineering Record on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

Remittances.—Remittances should be made by check, New York draft, or money order, in favor of The Engineering Record.

Changes of Address.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

Back Copies.—No copies of issues prior to July, 1906, are kept on sale, except in bound volumes.

Date on Wrapper indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

Club Rate.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. The rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1907, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 14,500 copies are printed. Total circulation for 1907 to date, 611,500 copies, an average of 14,560 copies per week.

TABLE OF LEADING ARTICLES.

Power Load as an Equalizer of Output.............. 415
Impermeable Concrete 415
Cost of Industrial Service......................... 416
The Utilization of Peat............................ 416
The Electrification of the Erie's Rochester Division. 417
Three Low-Head Hydro-Electric Developments in Michigan—Part I. (Illustrated)................... 418
The Manhattan Bridge Pedestals. (Illustrated)..... 423
Underpinning a 400-Ton Pier. (Illustrated)........ 426
Heating System of the St. Francis Home, Detroit, Mich. (Illustrated) 427
Granite-Top Macadam Pavement in St. Paul, Minn. (Illustrated) 430
Erecting Six-Track Plate Girder Bridges with a Derrick Car. (Illustrated) 430
The Rehabilitation of the Tracks of the Chicago Street Railway. (Illustrated)..................... 432
A Year's Experience with Gas Engines............. 434
Power Plant of the Gulfport and Mississippi Coast Traction Co. (Illustrated)........................ 435
Care of Electric Railway Tracks................... 436
A New Flexible Connection for Suction Pipes for Dredges. (Illustrated) 438
Large Impulse Wheels for a Brazilian Hydro-Electric Station. (Illustrated) 439
The Para Harbor Improvements...................... 440
A Machine for Tunneling in Shale.................. 440
Book Notes 441
Cost of Hauling Farm Products to Market.......... 441
The New Waihee Canal.............................. 442

The Power Load as an Equalizer of Output.

In the central station industry the growth of the power business has modified the conditions of current generation to a remarkable extent, enabling the machinery to be utilized at hours when it would otherwise stand idle and altering the shape of the load curve beyond all precedent. There is a lesson in this for the general power producer, although in an industrial plant the conditions are greatly narrowed, in comparison with the operating flexibility of a well-designed central station. The influence of the power load on a large scale appears daily in plants like that at Niagara, Montreal and other great centers of electrical generation or distribution.

The ordinary load curve of a lighting plant is characterized by a pronounced peak in the late afternoon or early evening, necessitating the maintenance of considerable extra generating capacity throughout the day and raising the fixed charges correspondingly. The results which can be secured by a judicious cultivation of power business are little short of remarkable in a large system, measuring their effect upon the load peaks. In Montreal, for example, the connected power load aggregates 37,000 h. p., and the connected lighting load 30,000 h. p. On a typical summer day last August the total output of the Montreal Light, Heat and Power Co.'s stations was held within a close average of 25,000 h. p. from 7:30 a. m. to 6 p. m., except during the noon hour. The mean variation in load was less than 4,000 h. p., and the lighting peak of 8 p. m. did not reach the maximum of the day load. Doubtless these results could not be duplicated in the winter season, but they show the value of a large distributed motor load in any plant which caters to a considerable lighting business.

Impermeable Concrete.

One of the most desired characteristics of concrete at the present time in connection with its physical resistance to the results of loading is impermeability to water. Although the ultimate compressive resistance of the strongest concrete is far below that of the best natural building stones, it is high enough to meet the exacting requirements of masonry in most engineering structures, and its lack of tensile resistance is effectively cured by steel reinforcement. In spite of the fact that its real merits, intrinsically of a high order, have at times been greatly exaggerated and grossly overworked by ignorant and ill-judged advocates, concrete is rapidly becoming one of the most valuable of all our structural materials for engineering purposes, if, indeed, it has not already reached that position. It is employed in many cases where its main function is that of carrying loads, but at the same time where the quality of real impermeability would add greatly to its value. This is not only true in an extended range of engineering structures, such as dams and aqueducts, but also in its application to buildings both en masse and in blocks. If concrete could be given a truly impermeable character its value would be greatly enhanced and its field of usefulness would be even more rapidly extended that at present.

The great obstacle heretofore experienced in making concrete waterproof has been its highly porous character. With the dry mixtures used in times past, the porosity of concrete was excessive and not the least of the many advantages accruing to the use of wet mixtures is the greater solidity or density conferred upon the mass. A wet mixture not only causes all portions of the mass to run together in greater solidity but it enables the finer materials of the aggregate to flow freely and thoroughly into the spaces between the coarser particles, thus producing a much more nearly continuous and dense interior mass. This means obviously a greatly reduced permeability to water or a much enhanced capacity to resist seepage through it. In fact, if the cement were ground sufficiently fine to enable it and the finest parts of the sand to enter freely into all the interior spaces of the aggregate, a waterproof material under high intensities of pressure would result; but the wettest mixtures which it is possible to use neither eliminate all the air bubbles nor fill all the interior spaces. However, much care may be taken in securing a thorough and intimate admixture of the component parts, all porosity is not eliminated and some seepage results under pressures of forty to sixty pounds per square inch or even less.

If suitably mixed concrete could be put under a high pressure before the initial set takes place, so as to squeeze out all air and surplus water, should there be any, in much the same way as molten steel is compressed, in order to produce grades of that metal of special value, it is altogether probable that the resulting density would be sufficient to secure essential impermeability under very high heads. This obviously is impossble, but some recent investigations appear to indicate that there may be other simple means of attaining the much-desired quality of impermeability. In a discussion by Mr. Richard H. Gaines of the paper presented to the American Society of Civil Engineers in April of the current year by Messrs. W. B. Fuller and S. E. Thompson, there are set forth some results of tests made to determine the effect of the addition of certain substances on ordinary concrete mixtures. In the search for materials which may enhance the waterproof character of concrete it is clear that none must be used which will prejudice the resistance or durability of the mixture. Mr. Gaines, who is the chemist of the New York Board of Water Supply, shows that the addition of small percentages of alum solution and fine clay to Portland cement mortar and concrete enhances greatly the impermeability of the mixture and that both compressive and tensile resistances were increased. Although the number of the tests was relatively small and the life of the test specimens was not long enough to settle conclusively such a question as that under consideration, the results obtained show that the line of investigation followed is worthy of being carried further in order to determine just what value may be attached to the mixtures of such materials as were employed with the usual proportions of cement, sand and gravel or broken stone in the manufacture of mortar and concrete.

It has been indicated by tests that, contrary to the former opinions of engineers, the presence of small percentages of fine clay of a suitable character and properly mixed does not necessarily injure the strength of concrete, and it has also been shown that the same mixture may aid in attaining more nearly waterproof qualities. Up to the present time, however, investigations of this kind have not been carried far enough to give quantitative results of sufficient range for practical purposes. It has generally been considered that the effect of fine clay in reducing the porosity of concrete was wholly mechanical, but the modern view of physical chemistry, so to speak, may disclose a different significance to the results of use of fine clay for such a purpose. With the modern wet concrete mixtures, the presence of the clay is asserted by Mr. Gaines to induce a colloidal action which is apparently aided by such a solution as that of alum, so that the result is a modification of the interior mass, tending to eliminate ordinary porosity.

There is nothing new in the employment of an alum solution as well as various soap solutions to afford concrete a certain degree of impermeability to water, but the purpose hitherto has been to produce an impermeable surface rather than an impermeable mass, which the results of Mr. Gaines' experimental work appear to indicate as attainable. The great advantage of securing an impermeable or waterproof mass of concrete over superficial effects is so clear as to need no comment. This observation is especially pertinent to all reinforced concrete work, in which it is of the first importance to protect the steel reinforcement from corrosion. It is to be hoped that in its investigations connected with the construction of the Catskill aqueduct, the Board of Water Supply will extend its investigations thoroughly into the field indicated by the results already obtained by Mr. Gaines. At the present time it is difficult to imagine any greater benefit to be conferred upon all classes of concrete work than to find some simple and effective method of making it waterproof under reasonably high pressures. Such an investigation should also include tests with hydrated lime and the various proprietary waterproofing compounds now extensively used, some of which seem to be giving good results when added to the usual concrete mixtures.

The Cost of Industrial Service.

A peculiar feature of many industrial organizations is the difficulty with which actual operating costs are determined for separate departments or classes of service. Questions of engineering are so often involved in these problems that it is worth while to consider some of the weak spots in the study of costs, especially in technical plants. It is very important for some of these organizations, particularly public service corporations under the fire of popular criticism, to be able to determine with a fair degree of accuracy what it costs to serve different classes of customers. Such information may be withheld from publication advisedly, but if a company does not know what its service costs in detail, it is certain to be misunderstood by outsiders. The idea is widely held that failure to figure detail costs of service covers abnormal profits. The central station ought to know fairly closely what it costs to serve a suburban customer in comparison with a heavy consumer in the business district, and the telephone company ought to have some reasonably good method of finding out what party line service costs it as compared with private line service. The manufacturing plant ought to know pretty closely the total operating expenses and fixed charges, either in its different departments or for a given class of products.

It must be admitted that the determination of such costs is a complex problem in many instances. The mere fact that two kinds of coal are burned in different furnaces in a plant, for example, means that every pound burned must first be weighed and charged against the proper process or furnace, if the fuel cost in each furnace or process is to be known. This simple case is often overlooked, and the total amount of each kind of coal burned recorded without reference to the use which was made of it. Perhaps it is guessed what each process took in fuel, but the total figures are generally given alone in such cases, or lumped in the total of the entire operating expenses of the plant. The fact is that the combined experience and judgment of the accountant and the engineer are needed in all but the simpler problems. The classification of accounts needs the scrutiny of the technical staff before it is established as a standard method of analysis.

The engineer can help in securing these segregated costs more than is often realized by the commercial man. Financial problems are closely associated with the planning of all-important tasks in engineering, and the money side must be recognized in operation, no less. Just as in buying materials and equipment the engineer can save the non-technical purchasing agent endless trouble if he is consulted at difficult junctures, so can he help the auditor and the bookkeeper in unravelling the intricacies of new technical combinations and relations in a growing industry. In the routine determination of costs the engineer can make certain that proper methods of measuring power, of counting and weighing materials, and of figuring labor costs are practiced. As a general rule, a physical separation of materials, supplies or products at the right time in the manufacturing process is the fundamental requisite for the securing of an accurate basis of cost calculation. This is the task of the betterment engineer and the production expert in a great many cases, but it is within the province of the regular engineering staff of a company to provide the necessary facilities for keeping an accurate count or measurement of the substances and agents pressed into its services and to be included in the separated operating expenses of the organization.

General expenses and fixed charges deserve the examination of the engineer in many of these companies, no less than pure operating expenses. The actual amounts of money diverted to this or that use is not the point at issue so much as the principle by which the charges are made. Knowledge of construction and replacement expenses can often be supplied by the engineering staff with far greater accuracy than is obtained from non-technical clerical figures. Arbitrary assumptions are no doubt often necessary in estimating general and fixed costs, and here technical knowledge of the conditions of a given industry is a valuable check upon the errors in judgment natural to the clerical department obliged to deal on its own initiative with involved relations between processes and employees.

The Utilization of Peat.

The renewed interest shown in the utilization of American peat bogs may possibly be traced to the activities of the American Peat Association, organized largely by members of the technical staff of the United States Geological Survey. This new society will hold its first meeting at the Jamestown Exposition the last of this month, and at that time we shall probably have an opportunity to learn more definitely just what degree of practicability there may be in the proposed utilization of peat in this country. According to a report by Mr. M. R. Campbell to the U. S. Geological Survey, there was not any very marked interest shown in the subject. About the usual number of companies were organized and glowing prospectuses were issued, but little or nothing was done toward the development of the peat industry in general. Many of the plants that were in operation experimentally in 1905 closed down during the year, he states, so that at the end of 1906 it is probable that there were fewer plants in operation than at the close of 1905.

According to Mr. Campbell's report, three companies have worked on an experimental scale in 1906 in this country. The Winter Park Electric & Fuel Co., in Orlando, Fla., which uses the Leavitt machine; the Wolverine Peat Fuel Co., near Vicksburg, Mich., which uses the Dolberg machine, and the Lamertine Heat, Light & Power Co., near Vicksburg, Mich., which uses a machine of special type owned by the company. The method of handling the peat is essentially the same in the three plants, namely, digging from bog either by hand or machine; transporting in car or conveying apparatus to mill; disintegrating in mill; molding into bricks, and finally drying by natural exposure until the water is reduced to about 15 or 20 per cent. The Winter Park Electric & Fuel Co. has departed from this practice slightly, as it now dispenses with the molding into bricks, simply dumping the disintegrated peat on the ground and letting it dry in irregular masses, which later are broken with hammers into lumps. This is reported to give excellent satisfaction; it is cheaper, though it requires more space for storage. A very complete plant, that of the International Fuel & Power Co., is nearly ready for operation at a bog located not far from Ogdensburg, N. Y. It is built on a large dredge, and the progress of the peat through the machine from the time it leaves the bog until it is delivered in the form of briquettes is entirely automatic. The bog is located on the east side of Black Lake, in a position that makes dredging operation easy. The peat is raised from the bog in bucket conveyors, dropped into the hopper of a disintegrating machine, passed through steam-jacketed pipes to drive off moisture, and then, while hot, is briquetted under immense pressure. The product, according to the claims of the company, contains less than 5 per cent. of moisture.

The reasons for the interest in this problem of utilizing peat are discussed at considerable length in the "Electrochemical and Metallurgical Industry" of the current month. The chief reasons are on one side, the enormous extension of peat deposit areas, at present practically worthless, and on the other side the undeniable fact that peat, according to its chemical composition, contains so considerable material values and energy values that their recovery would be highly desirable. But the process of recovery should be cheap, its cost should certainly be considerably less than the amount of the values to be recovered. This is the great difficulty. We might compare the peat problem with a very low-grade ore proposition. As long as high-grade ores are available, low-grade ore propositions are not very attractive. But in recent years we have seen great changes in the attractiveness of such propositions in the case of several metals, both as the result of the scarcity of high-grade ore and of the advances made in the metallurgical art. The peat problem may be considered from the same point of view. There have been considerable changes in recent years in the object aimed at as well as in the means for handling the peat.

In the old peat problem the object was to convert the peat into fuel suitable for both domestic and steaming purposes, this fuel to be shipped to consumers to compete with coal. In the new peat problem the object is to erect plants in the peat districts themselves for recovery of the values. Two essentially different means are available. One is dry distillation for the production of coke, with recovery of the by-products. The other is using the peat in gas producers for the production of power, also with recovery of by-products. With respect to the by-products, the nitrogen content of the peat is significant, since it is possible to recover it in form of ammonium sulphate; in view of the rapidly increasing importance of the artificial fertilizer industry the fixation of the nitrogen in peat is certainly as attractive a problem as the fixation of atmospheric nitrogen. Concerning the coke produced from dry distillation of peat it is to be pointed out that its quality naturally depends on the composition of the raw peat, especially its ash contents, but that its freedom from sulphur should go a long way to make peat coke desirable for metallurgical purposes. Finally, as to the desirability of producing cheap power from peat there can hardly be any disagreement of opinion. If power can be produced cheap enough there will be uses for it even in peat districts which have not yet any industry.

All the essential troubles with peat are due to its content of water and to its porosity. Much has been done in the construction of suitable machinery for kneading and treating the peat, so as to mold it and remove a considerable portion of the water. For the dry distillation of peat, the enormous advances which have been made in by-product coke ovens for the dry distillation of coal are of direct importance. Finally, as to the development of power from peat, the whole idea of doing this has become possible only through the development of the modern gas producer and large gas engine. It is evident there are vast possibilities, but it should not be amiss to finally sum up what has been actually achieved.

The Electrification of the Erie's Rochester Division.

The comprehensive description by Mr. W. N. Smith, of the electrification of the Rochester Division of the Erie R. R., printed last week, has a double interest in that the line in question was not only the first to use single-phase motors in regular railway traffic, but also utilizes for this traffic power transmitted at 60,000 volts from Niagara.

By a combination of energy and good fortune, too, the road went into operation some months ahead of the electric system of the N. Y., N. H. & H. R. R., on which work had been long in progress. It is a capital example of the easy applicability of single-phase high voltage traction to existing steam roads, leaving the freight service undisturbed, to be taken up later if desirable The system involves many novelties and many very ingenious features of construction. To begin with the high-tension transmission line, one finds here an unusual type of construction, forming an ingenious compromise between the ordinary pole line and the tower system which has of late come into extensive use. It employs an A frame for the support of the wires, composed of two heavy cypress poles united at the top. In virtue of the extra support thus given the normal span is lengthened to 220 ft., thus greatly decreasing the number of insulators.

The lightning protection is also out of the ordinary, horn arresters being installed at every fifth pole. It is, of course, early to speak of the efficiency of this particular feature, but the horn arrester, although somewhat insensitive, has given a good account of itself on some of the important lines on the Pacific Coast and requires little attention, a great virtue in case of its use on pole lines. At the sub-station the lightning protection is more elaborate, consisting of three horn arresters in series, grounded respectively through a concrete column, an electrolytic arrester and a copper fuse wire. The special feature of the sub-station arrangements is the ingenious utilization of the three-phase-two-phase transformation, the two resultant single-phase currents being transmitted over the two nearly equal sections of the road to the north and south of the sub-station respectively. The actual working conductors thus fed are of No. 000 ground copper, carried by a catenary bracket construction. An interesting feature of this is that each steel bracket is permanently grounded to the rails, so that the failure of an insulator means a dead short circuit, the intention being to avoid any danger of poles burning off and obstructing traffic in case of a partial ground. Another safety precaution adopted is the abolition of practically all telegraph and telephone wire overhead crossings, such wires being taken under the track by cables. In a few cases, to which cables could not be conveniently applied, a basket construction of guard wires has been used to obviate any chance of crosses with the high-tension trolley wire.

On the motor car the equipment consists of four 100-h.-p. motors with Westinghouse electro-pneumatic control. Many ingenious details have been here introduced to provide for safe and certain operation. The service undertaken over the 34-mile line is based on the use of motor cars capable of handling a single trailer when desirable, at an average schedule speed of 24 miles per hour. There are 6 regular stations on the line and 22 flag stations, at some or all of which stops are to be made, so that to maintain schedule a flexible speed control such as this system furnishes is highly important. Experience has already shown that the electric trains can be made to hold the schedule rather better than the steam trains which they have supplanted. The operation of the four classes of trains employed, viz., electric, steam passenger, through freight and local freight, over a single-track road such as the Rochester branch is, involved some complications, but these have been successfully overcome.

Of the technical problems arising for solution in this plant one of the most serious was the interference produced by the current upon telegraph and telephone lines in the vicinity. On an ordinary transmission line such trouble is not formidable, for by proper transposition the inductive effects can be reduced to comparative insignificance. On this single-phase system with track return, kept in electrical instability by the shifting of the load both the electro-dynamic and electro-static effects were very noticeable, especially the latter. No suitable means of eliminating the trouble by working upon the line itself was found, but it did prove practicable to remove the baneful influence by providing the telegraph relays with fairly high resistance discharging shunts. This obviated the necessity of complete metallic circuits for the telegraph service. Such circuits are now in general use for telephone work, and if properly installed give good service, even in proximity to a single-phase line. This result is very satisfactory, since the question of interference from such systems has been a matter of no small concern. Altogether the engineering work on this Rochester division of the Erie seems to have given suitable solutions for a good many of the practical problems of single-phase teaching, and will probably lead to a freer use of the system than has heretofore been judged discreet.

Notes and Comments.

Rail Corrugations have been investigated by a committee of the American Street and Interurban Railway Engineering Association, and its inquiries show a great variance in the experience with these troubles. It appears that corrugations have been observed in different types of rails, and that the length affected ranges from a yard to several hundred feet. Sometimes the corrugations have appeared within a few months after the rails were laid, and in other places they were detected only after the rails had been in use a number of years. The length of the individual corrugations is 1 to 15 in., and their depth is sometimes as much as 3/16 in. Apparently deep girder rails are most liable to become corrugated. Seven companies have detected corrugations on the outer rails of light curves, one company on the inner rail of light curves, and three companies in straight track. Braking seems to have little effect in causing them although three companies find corrugations where brakes are applied most frequently.

The Excavation Records being made at the Isthmus of Panama are of the most gratifying nature. The total excavation for September was 1,517,412 cu. yds., which not only exceeds the amount taken out in any previous month, but all estimates for a month. These figures include about 36,000 yd. of material taken outside of the canal prism in accessory work, but work on the prism exceeds by nearly 207,000 yd. the excavation of the prism for August. This record is particularly remarkable for the fact that nearly 12 in. of rain fell during September, a slight excess over the rainfall in August and nearly 3 in. more than that in July. The relocation of the Panama Railroad is proceeding rapidly, and during August over 65,000 yd. of material were placed in the new embankment. The general indications are that the excavation from now on will considerably exceed the rate necessary to keep pace with the construction of the locks and dams, to the promotion of which Colonel Goethals is now devoting special attention. These conditions are noteworthy because heretofore the rainy season has been looked upon as a probable check to the forward progress of excavation work. The fact that such records have been made is to be accepted as conclusive proof that the stories of dissension among the Commission's employees are without basis, for no such progress would be possible were dissension rife.

The Manufacture of Public Opinion concerning engineering works of the greatest magnitude was well described recently by witnesses in the investigation which the Public Service Commission is making into the affairs of the Metropolitan Street Railway of New York. It is perfectly well known that public opinion on engineering works is so manufactured, although very few of those signing petitions or attending mass meetings know the extent to which they are manipulated. For one reason or another some corporation, city or state may find it desirable to have a certain kind of undertaking pushed forward rapidly or else hindered as much as possible. The ways in which it proceeds to arouse the interest of the public to its way of thinking are manifold. In the special case referred to, a lawyer was employed who succeeded in having petitions signed by many thousands of people in favor of certain rapid transit plans, one of these petitions being signed by over a million residents of Greater New York. It is, of course, possible that a great many of these signers of these petitions thought they were acting voluntarily in the matter, but the contrary was the case. The same lawyer who engaged people to circulate these petitions assisted in forming various associations of citizens in different sections of the city for the same purpose, the expenses in every case being comparatively small when the enormous interests involved were considered.

The Condition of the Ship-Building Industry in the United States is outlined in a report of the Census Bureau just completed. In 1880, according to these figures, there were 2,188 ship-building plants in the country, while in 1904 there were but 1,097. In the former year the capital invested was approximately $21,000,000, but in 1904 the investment had increased to $121,600,000; the number of employees increasing from about 21,000 to nearly 51,000 in the same period. The value of the work done was about $37,000,000 in 1880 and about $83,000,000 in 1904. The changes have been largely due to the shutting down of small plants building wooden vessels and the great development of the steel ship industry. Since 1900 there has been an increase of over 50 per cent. in the production of boats under 5-ton rating, due to the development of gasoline engines for such craft. About three-fourths of the total value of the products of the ship-building industry in 1904 came from establishments in the Atlantic and Gulf districts. Although the number of ship-building plants in the Great Lakes district was nearly double the number in the Pacific Coast district, the output of the latter was slightly greater than that of the former. Although the number of vessels of 5 tons and over launched during 1904 was 167 less than the number launched in 1880, the tonnage had increased 40½ per cent. during this period. The average value of the vessels launched in 1880 was not quite $8,000 whereas in 1905 the average value was $32,700.

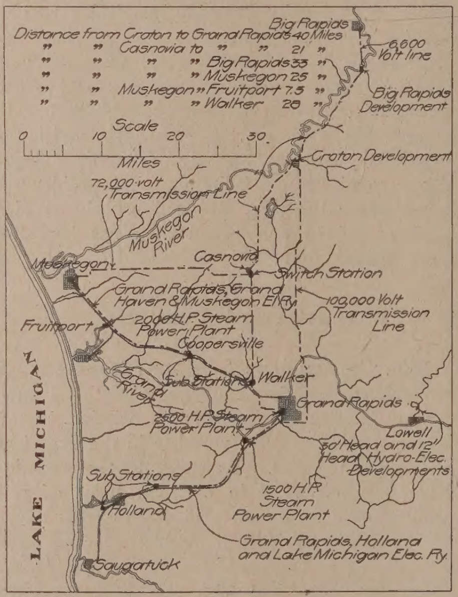
THREE LOW-HEAD HYDRO-ELECTRIC DEVELOPMENTS IN MICHIGAN.—PART I.

Three low-head hydro-electric developments, involving a number of similar features of design and construction, have been placed in service recently in the southern and western parts of Michigan. Two of these developments are a part of the system of the Grand Rapids-Muskegon Power Co., of Grand Rapids, Mich., and the third was built by the Commonwealth Power Co., of Jackson, Mich. The financial interests of these two companies are allied, but their generating systems and the fields of their operations are entirely distinct. Electric current is generated by the former company in two steam-driven stations and by four hydro-electric developments. The steam-driven installations are part of existing systems that were acquired by the company; two of the hydro-electric developments are on the Muskegon River, and the other two are on the Flat River, a tributary of the Grand River. The Commonwealth Power Co. operates seven hydro-electric stations, one on the Grand River and six on the Kalamazoo River.

The Grand Rapids-Muskegon Power Co. supplies power to operate two interurban electric railway lines which enter Grand Rapids; to the Grand Rapids Edison Co.; to several large factories in Grand Rapids and Muskegon; and for commercial lighting in Big Rapids, Coopersville and Grandville. The location of the various generating stations and transmission lines of this company, and of the two interurban railways supplied with power by it, is shown in an accompanying map of the district covered. The two hydro-electric developments on the Muskegon River are at Croton and near Big Rapids, 43 and 58 miles, respectively, from Muskegon, which is at the mouth of the river, and 40 and 50 miles from Grand Rapids. Power is transmitted from both stations to Grand Rapids and to Muskegon. The two developments on the Flat River are at Lowell, 18 miles east of Grand Rapids, to which the power generated in them is transmitted. One of the interurban electric railways extends from Grand Rapids to Muskegon, and the other from Grand Rapids through Holland to Saugatuck, on Lake Michigan. A 2,000-h.-p. steam-driven station on the Grand Rapids-Muskegon interurban system and a 1,500-h.-p. steam-driven station on the Grand Rapids-Saugatuck line are connected with the general distribution system. The company also controls dam sites on the Muskegon and Grand Rivers, which, including those already developed, will produce an ultimate capacity of 60,000 h.-p.

The Muskegon River is the longest river in Michigan, its general course being from the north to the south. The river has its source in Higgins and Houghton Lakes, which have a combined area of about 50 square miles. The entire catchment area of about 1,800 square miles above the Big Rapids dam has a clay subsoil, overlaid to a depth of about 10 ft. with sand and gravel, and is mostly covered with a growth of scrub pines and oak. The rainfall is therefore largely absorbed by the soil and is delivered slowly to the streams. The course of the river from the north to south, together with its considerable length, causes thawing of the snow in the Spring to begin at the mouth of the river, and to proceed northward gradually, so considerable Spring floods due to a quick thaw over the entire watershed are uncommon. This normal absence of spring floods and the slow delivery of the rainfall to the streams makes the variation between high-water and low-water flows comparatively small. In fact, the minimum flow of record at the Big Dam is 700 second feet, which occurred Sept. 2, 1907, while the maximum is 5,900 second-feet, occurring in March, 1904. Practically the same stream-flow conditions also exist at the Croton development, where the total watershed above the dam is approximately 2,300 square miles. The variation between the minimum and maximum flows is proportionately somewhat greater at this dam than at the Big Rapids dam, however, as the Little Muskegon River, with a watershed tending toward a more rapid discharge of the rainfall, enters the main river between the two dams. The relatively high minimum flow and the uniform flow throughout the year, together with a rapid fall in the middle section of the river, indicate the value of the stream for power developments.

Croton Development.—The development at Croton, which is the more important of the two on the Muskegon River, renders available a head of 40 ft., and contains equipment with a capacity for developing continuously 14,400 h.-p. It was built at a bend in the river, where the valley is 600 ft. wide, with a bank a little over 40 ft., high on one side and one 120 ft. high above the water on the other side. The works that make up the dam embrace essentially the following: A waste-gate section, 238.75 ft. long, which is built of concrete and is at one side of the river valley; a power house, 160 ft. long, that adjoins the outer end of the waste-gate section; and a hydraulic-fill embankment, 200 ft. long, extending from the power house to the high bluff on the opposite side of the valley. One of the chief features of the design of the dam, and of the dams at the other two developments to be described, is the use of flood gates of sufficient capacity and so arranged that the pond above the dam is maintained at a constant level throughout the year. These flood gates are of the Tainter type, built of steel, each gate being 20 ft. wide and 12 or 13 ft. high. Another feature of the hydraulic design common to all three developments is that the water is discharged from the waste gates into a tumble bay, from which it spills over a low concrete weir into a waste channel.


Distance from Croton to Grand Rapids 40 Miles
" " Casnovia to " " 21 "
" " " " Big Rapids 33 "
" " " " Muskegon 25 "
" " Muskegon " Fruitport 7.5 "
" " " " Walker 28 "
Scale
0
10
20
30
Miles
Big Rapids
6,600 Volt line
Big Rapids Development
Croton Development
72,000 volt Transmission Line
Muskegon River
Muskegon
Casnovia
Switch Station
Grand Rapids, Grand Haven & Muskegon El. Ry.
100,000 Volt Transmission Line
Fruitport
2000 H.P. Steam Power Plant
Coopersville
Grand River
Sub Stations
Walker
Grand Rapids
2500 H.P. Steam Power Plant
Lowell
30' Head and 12' Head Hydro-Elec. Developments
Sub Stations
Holland
1500 H.P. Steam Power Plant
Grand Rapids, Holland and Lake Michigan Elec. Ry.
Saugatuck
LAKE MICHIGAN

Map Showing Hydro-Electric Developments and Transmission Lines of the Grand Rapids-Muskegon Power Co.

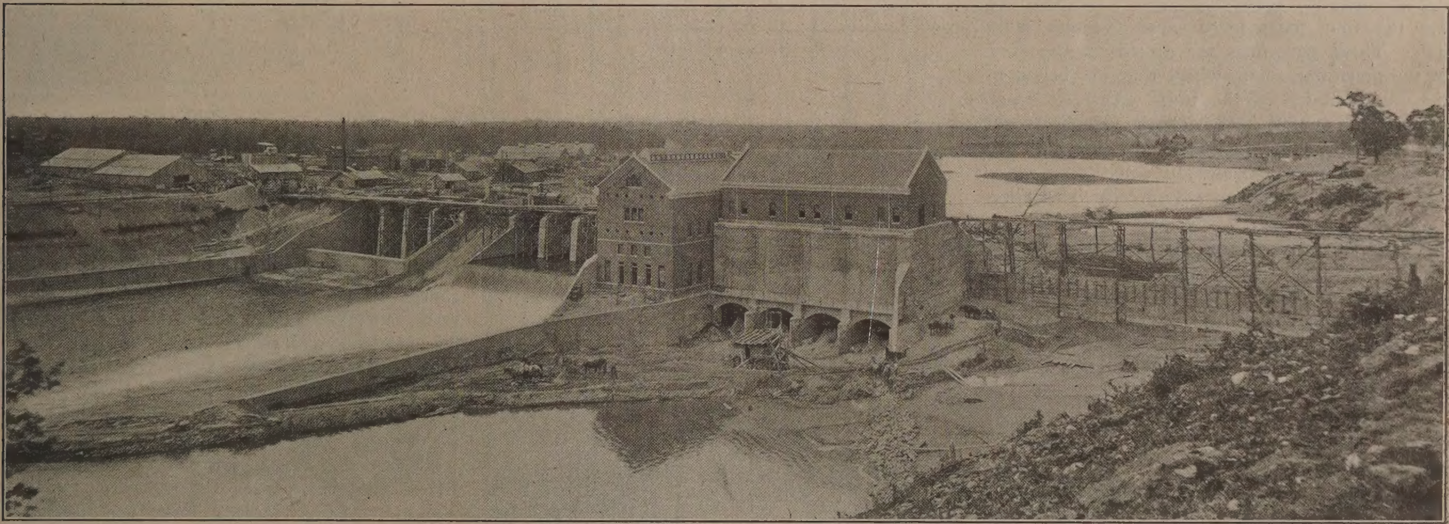
The site of the development at Croton is underlaid at a depth of 20 to 40 ft. below the surface by a stratum of hardpan, deposits of sand, gravel and clay overlying this hardpan. A continuous row of steel sheet piling was driven far enough into the hardpan under the waste-gate section and the power house to form an effective cut-off; this row of piling was also continued from the power house across to the opposite side of the valley, under a corewall in the embankment. The waste-gate section and the power house are carried largely by round wooden piles driven to the hardpan. They were both built on a flat at one side of the river channel, almost without encroaching on the latter. After they were finished the river was diverted through temporary openings in the waste-gate section and the hydraulic-fill embankment was built across the channel.

Waste-Gate Section.—The waste-gate section contains eight Tainter gates, each 20 ft. in width, and a log sluice, 40 ft. wide, that is controlled by a 40 x 3.5-ft. movable crest, or bear-trap dam. Four of the Tainter gates are on each side of the log sluice, the adjacent gates being separated by heavy concrete piers. The normal water surface in the pond above the dam is at Elevation 135.5, while the upper edge of the gates when closed is at Elevation 136, and the water in the tail race is at Elevation 95. The gates seat on a spillway which has a hollow reinforced-concrete gravity section. The details of the design of this spillway, the arrangement of the tumble bay and the concrete apron for the waste-way channel below the dam are shown in an accompanying cross-sectional elevation through the waste-gate section of the dam. The base of the downstream edge of the spillway is 45 ft. 8 in. from the upstream edge of the crest of the weir which forms the tumble bay. The crest of this weir is 7.5 ft. above the heavy reinforced-concrete floor of the tumble bay, this floor being continuous with the base of the dam. A concrete wall is continued from the piers on each side of the log sluice to the overflow weir, thus separating the tumble bay into two parts. Each of these parts has three 12-in. circular weepers connecting it with the tail race, so by closing the four Tainter gates on either side of the log sluice, the corresponding part of the tumble bay can be drained and the under side of the hollow spillway section entered from it.

The bottom of the waste-way channel below the gate section is protected by a reinforced-concrete apron that extends downstream for 200 ft. from the overflow weir of the tumble bay. The bottom of the log sluice is on a slope of 8 in. to the foot, a vertical curve connecting it with the apron protection for the waste-way channel. The retaining walls on each side of the sluice are also continued 20 ft. downstream from the overflow weir of the tumble bays so the flow through the sluice and that over the weir at each side of it are separated. A reinforced-concrete wall, extending downstream to the end of the protection apron separates the waste-way channel and the tail race of the power house. This wall is reduced in height from a maximum of 35 ft. at the power house to 10 ft. at the downstream end, and largely prevents back water in the tail race.

The Tainter gates were specially designed for the three developments that are to be described herewith. Each gate swings on two bearings, one on the pier on each side of the opening which it controls. These bearings are on 6-in. cold-rolled, turned, steel pins, that are imbedded in the piers. The frames of the gates are trussed across so these pins are only required to extend about 1 ft. from the face of pier, thus eliminating the usual bearing at the center of the gate and the necessity of providing a long, heavy steel shaft to extend the width of the gate.

Each gate is fitted along the lower edge of its face with a heavy oak block, which, when the gate is lowered, seats on a wooden sill carried by a 15-in. channel imbedded in the crest of the spillway of the dam. This arrangement makes a



General View of Croton Development Showing Embankment Being Sluiced into Original River Channel.

watertight joint, that it is considered will rarely have to be renewed. The joints between the ends of the gates and the surface of the piers between the gates are made practically watertight by attaching 5-in. strips of 3-ply rubber belting to the edge of the upstream face of the gate in such manner that the belting overlaps the end of the gate and bears against the face of the concrete pier.

The gates are raised and lowered by a motor-driven hoisting crab that travels on a 24-in. gauge track of 12-in. I-beams laid the length of the waste-gate section on the piers between the gates and covered with a light section of reinforced-concrete so as to bridge the openings between these piers. This crab consists essentially of an eight-wheel truck, 18 ft. long, that carries a 4-h.-p. motor, worm-geared, through reductions to a horizontal shaft having a grooved drum attached to each end of it. One of these drums is built as a right-hand and the other as a left-hand screw. Each gate has a shackle attached to it at both ends near the bottom of the face, these shackles being arranged so chains can be hooked into them and wound around the drums of the hoisting crab. An 8,000-lb. pull can be exerted on each of these chains by the crab, so the gates are easily handled by the latter. Power to operate the motor is obtained from a supply line laid in a conduit buried in the concrete, plugs for making connections being placed at suitable intervals along the gate section. Two hoisting crabs are provided, in order to be certain of one, if the other is out of commission. Both crabs are also arranged with wheels, fitted with grips, so they may be operated by hand in case both motors are out of service, or no current is available.

Movable Crest Dam.—The movable crest dam is set in a depression built in the top of the spillway of the waste-gate section. It has a leaf, 6 ft. 10 in. wide and 40 ft. long, which turns on a shaft in a hinge along the upstream edge, thus permitting the downstream edge to be raised and lowered through a vertical travel of 3.5 ft. The leaf is raised and lowered by two sets of motor-operated worm and spur gears which drive two hoisting drums on a main shaft extending across the opening controlled by the movable crest. Two chains, one attached to each end of the leaf, are wound around these drums, the latter being grooved, one as a right and the other as a left-hand screw.

An 18-in. I-beam extends the full length of the 6-ft. 10-in. leaf, and is attached to the front edge of the latter.

The leaf turns on sections of 3-in. steel shaft. Bearings on this shaft are attached to the leaf at intervals of 6 ft. At about 6-ft. intervals intermediate with the bearings carrying the leaf are thrust bearings against the shaft, which are seated on heavy castings in the top of a concrete ledge under the hinge. The base of each of these thrust bearings is arranged with an adjusting screw so all the bearings may be brought into alignment.

Earth Embankment Section.—The earth embankment between the end of the power house and the side of the valley opposite from the waste-gate section contains 104,000 cu. yd. of sand and gravel that was sluiced into it hydraulically from the high bluff on that side of the valley. This embankment is 20 ft. wide on top, 40 to 60 ft. high, and has a slope of from 2½ to as much as 6 to 1 on its upstream side, while the slope on the downstream side is between 2 to 1 and 4 to 1. The concrete core wall in the embankment is 12 in. thick and is heavily reinforced. It rests on the line of steel sheet piling which forms the cut-off at the base of the dam. The wall is located at the line where the surface of the pond intersects the embankment, projecting 2 ft. above the water level to serve as a wave protection. With this arrangement the greater part of the embankment remains practically dry, giving it much greater stability than if saturated, while the line of sheet piling prevents seepage under the embankment.

Power House.—The power house is an L-shape structure, with the axis of the stem of the ell coincident with the axis of the dam. The stem of this L-shape building is 65 x 141 ft. in plan and has a heavy concrete substructure carrying the penstocks and containing the draft tubes for the water wheels. The leg of the ell is 44 x 80 ft. in plan, and contains the electrical equipment. This part of the building has hard-burned, red-brick walls, surmounted by a roof of glazed, green tile carried by steel roof trusses, the appearance of the exterior being very satisfactory. A low house, with the same kind of walls and roof, covers the penstocks.

The generator room of the power house contains two 3,600-kw. revolving-field 30-cycle 6,600-volt three-phase Westinghouse generators. Each generator is direct-connected by a 12-in. shaft, 110 ft. long, to four pairs of 45-in. Samson turbines, of the center discharge type, which are in the adjacent penstocks. The units operate normally at 225 r. p. m., but are designed to run without injury at double that speed with no load. The shafts are each also designed to carry 8,000 h.-p. continuously.

The shaft of the main units is at right angles to the stream and parallel with axis of the dam. The portion of the substructure of the building in which the turbines are placed is divided by transverse walls into four penstocks, each containing a pair of turbines for each unit. These penstocks are each 22 ft. wide and rise to a height of 33 ft. above the top of the heavy base on which the turbines are set, and in which the draft tubes for the latter are formed. The upper two-thirds of the front end of each penstock is open the full width of the penstock to form an entrance from the pond above the dam. These openings are each protected by an inclined rack, within the penstock, which intercepts floating debris. A heavy boom is also extended from each side of the log sluice in the waste-gate section to the sides of pond to divert logs and large floating debris over the sluice. Stop-log grooves are placed in both sides of each penstock, immediately in front of the rack, in order that the penstocks may be shut off separately. Light steel-frame gates, faced with planks and divided horizontally at the middle, are operated in these stop-log grooves. These gates are handled by a hoisting block running on an I-beam trolley suspended from the roof trusses of the house over the penstocks. The upper half of each gate can be hung on hooks on the side wall of the penstock house, when it has been lifted out, and the lower part is arranged to stand beside the upper part, both parts being placed in these positions for storage by the hoist.

The downstream ends and the sides of the penstocks are of reinforced concrete. These ends are semi-circular, with the reinforcement in them carried backward and downward into the base of the penstocks at an angle of about 45 deg. with the horizontal to overcome any tendency of shearing in the concrete. The sides and ends of the penstocks are designed so any one penstock may be emptied safely while the others are filled.

Each pair of turbines has a draft tube, leading to the tail race, formed in the heavy base on which the penstocks stand. The arrangement of the units normal to the stream, and the location of the corresponding pairs of turbines for both units on the same transverse line in the penstocks, necessitated a special and unusual design of these draft tubes. The upper part of the draft tubes for the pairs of turbines of the units on upstream side are as ordinarily built, but these tubes flare out at the bottom, so a draft tube for one of the pairs of turbines of the downstream unit can be placed in line with each of them. This increase of section is made in such a manner that the water discharged from the upstream turbine in each case passes on both sides of the draft tube for the corresponding downstream pair of turbines, the velocity of the water where the discharge from the two tubes join being the same, to eliminate as fully as possible any agitation at this point.

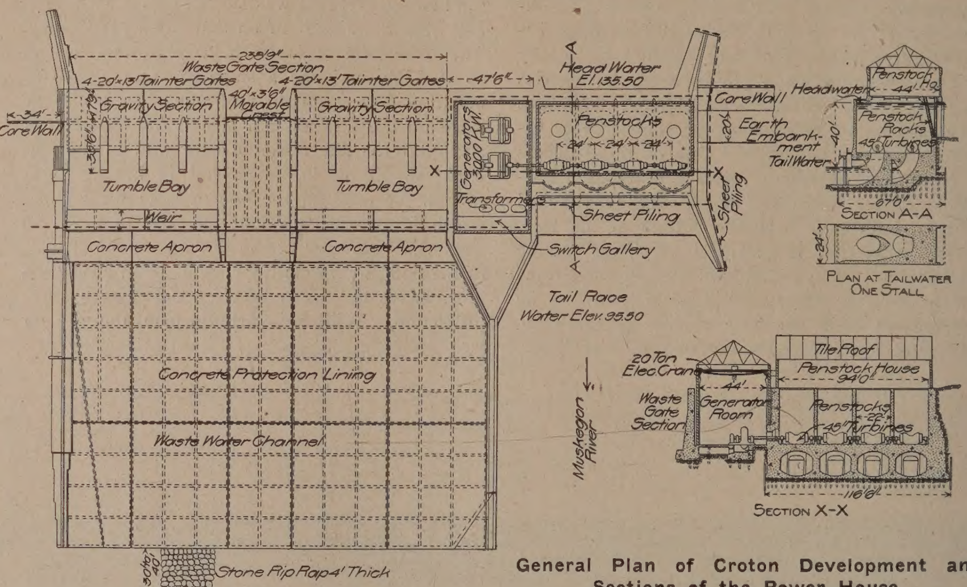
The shafts of the two units pass through large glands in each of the division walls between the penstocks, and in the wall between the end penstock and the generator room. These glands are each carried by a heavy cast-iron diaphragm attached to a frame of I-beams and channels imbedded in the walls. The frames for the various glands of each unit are anchored together by heavy iron rods extending from one end to the other of the row of penstocks. The glands are practically watertight, so any one penstock may be drained and entered without interfering with the operation of the turbines in the remainder. Stop-log grooves in each penstock between the corresponding turbines of the two units also permit the downstream turbines to be cut off without stopping the turbines of the upstream unit in the same penstock. Any pair of turbines on either shaft can also be disconnected so the other turbines between the pair in question and the generator may be continued in service.

Two Type N Lombard governors are provided for the four pairs of turbines to each main unit. These governors are placed on the floor of the generator room, where they are belted to the main shafts of the units. One governor controls the operation of two pairs of wheels and the second one the other two pairs, but both are arranged to operate simultaneously.

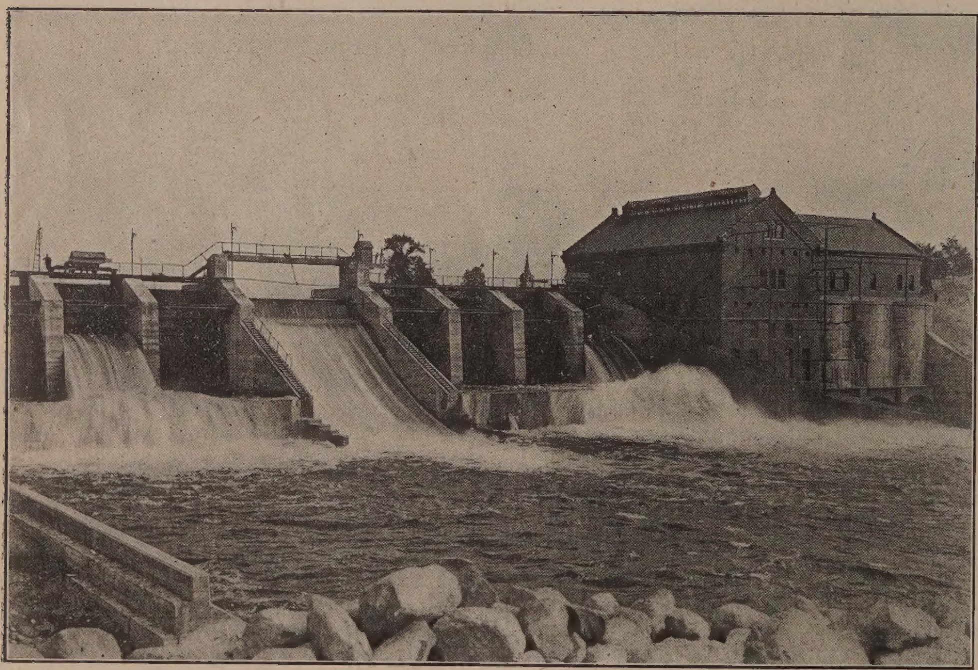
A complete mechanically-forced lubricating feed system is also provided for the bearings of the turbines of each unit, the bearings under water being of lignumvitae. Each of these systems consists essentially of a supply cylinder carrying a piston on a screw, by which heavy oil may be forced into small storage tanks under pressure. The supply cylinders and storage tanks are in the generator room on a bracket gallery against the wall which separates that room from the penstocks. The storage tanks are connected to a pipe header from which a separate lateral pipe is carried to each of the four bearings on every pair of turbines. These lateral pipes are each fitted with a quick-opening valve, which is opened for a short time when oil is to be supplied to a bearing, thus insuring a positive feed.

Excitation current for each main generator is furnished by a 40-kw. 125-volt direct-current generator on the shaft of the unit. The field winding of the generators is so proportioned that with constant speed, constant separate excitation and 100 per cent. load factor, the load may be varied from the normal rated capacity to no load with a voltage rise of not more than 8 per cent. At the normal rated current and voltage, and with 100 per cent. load factor, the efficiency of the generators is guaranteed to be at least 93 per cent. at half load; 95 per cent. at three-quarters load; 96 per cent. at full load; and 95.5 per cent. at 50 per cent. overload. Unusual care to prevent excessive temperatures in the generators under continuous operation was also observed in the design.

The 6,600-volt current delivered by the generators is stepped up to 72,000 or 100,000 volts for transmission to Muskegon and Grand Rapids by three 3,000-kw. 30-cycle oil-insulated water-cooled transformers, placed at the downstream end of the generator room. The transmission lines leading from the power house will be described later.



General Plan of Croton Development and Sections of the Power House.



Close View of Waste Gates and Log Sluice at Croton.

The operation of the generators is controlled from a two-panel switchboard at level of the generator room floor. Motor-operated oil switches, also controlled from this switchboard, are provided for the high-tension bus-bars and connections. These switches are in separate fireproof cells, and the bus-bars are all in separate fireproof compartments.

Construction of Croton Development.—The works which make up the Croton development were built on force account by the owner, the Grand Rapids-Muskegon Power Co., under the direction of Mr. J. B. Foote, general superintendent and electrical engineer, and Mr. William G. Fargo, designing and supervising engineer, in charge of the work. Mr. Daniel L. Davis was resident superintendent and Mr. Benj. T. Weston was resident engineer during the construction.

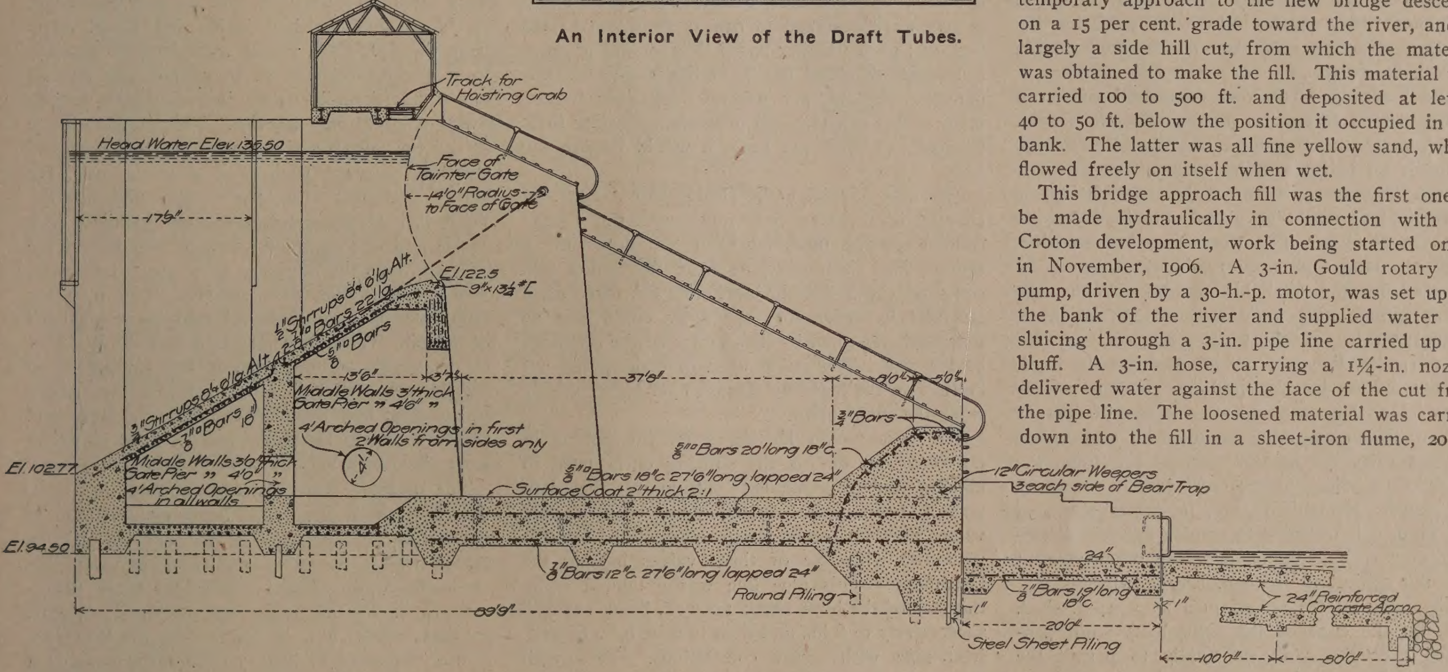
In order to facilitate the delivery of supplies and materials, a standard-gauge railroad, 6 miles long, was built from the Pere Marquette Ry. to the site. Standard-gauge switching connections with this branch railroad were extended to all parts of the storage yards at the works, these extensions being carried down on inclines so the turbines and electric machinery could be delivered close to the power house. Standard-gauge cars were handled on these inclines by electrically-driven hoists without any difficulty. A stationary gantry for a cross-travel trolley carrying a 10-ton chain hoist was built over one of the side tracks for unloading heavy material and machinery.

The construction plant for the work included two No. 1 Vulcan turntable pile drivers, two drop-hammer pile drivers, one ½-yd. and two ¾-yd. cubical mixers and a number of derricks, pumps and smaller equipment. All of this equipment was operated by motors, except the turntable pile drivers, which were operated by steam. A 9 x 11-in. motor-driven air compressor, with a capacity of 130 cu. ft. per minute, was also installed in a temporary boiler house on the low bank of the valley. This compressor furnished power for operating two riveting hammers, a chipping hammer, a reversible wood-boring machine and four forges in a blacksmith shop. The compressor and tools, exclusive of the motor and air tank, cost $600.

The electric power required to drive the various motors was supplied by a temporary 6,600-volt line extended to the site from the Big Rapids development, which had been completed before construction was started at the Croton dam. A 72,000-volt transmission line, extending from the Big Rapids development to a switch station, with one branch leading to Grand Rapids and a second branch to Muskegon from this station, passes the site of the development at Croton. The 6,600-volt line was carried on temporary brackets placed on the poles of this high tension line. The 6,600-volt current was stepped down to 440 volts by water-cooled transformers at Croton for use in the construction plant there.

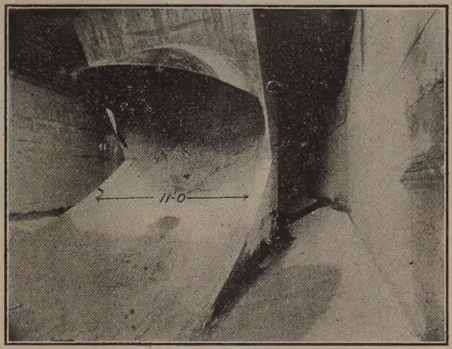
Concrete.—In all, about 20,000 cu. yd. of concrete were used in the dam. This concrete was made in varying proportions, depending on the purpose for which it was to be used. Newaygo Portland cement and unscreened pit gravel were used in all of the concrete. This gravel contained about the proper amount of sand, the voids in it ranging from 14 to 18 per cent. The gravel was obtained from a pit along the branch railroad about a mile from the dam, and was brought to the work in 5-yd. bottom-dump cars handled in trains of 10 cars each, by a standard-gauge locomotive.

A concrete mixing plant was erected near the end of the waste-gate section of the dam, in line with the axis of the latter and back on the edge of the low bluff on that side, about 40 ft. from the limits of the concrete work. The two ¾-yd. motor-driven mixers were set up in this plant so that they would dump into cars on tracks about level with the highest point of the concrete in the dam. A storage for gravel was erected over the mixers, the gravel being delivered into a track hopper at the side of the plant from cars on the standard-gauge railroad, from which hopper it was raised to the storage bin by a bucket elevator. The cement was stored in a shed in the rear of the mixing plant. An incline was extended from this shed up to a working platform around charging hoppers over the mixers and the cement was hauled up a track on this incline on flat cars handled by an electric hoist.



Cross Sectional Elevation through one of the Tainter Waste Gates at Croton.

A temporary pole trestle was extended from the mixing plant to the opposite side the valley, crossing the latter on the axis of the dam. This trestle carried two 24-in. gauge tracks, on which ½-yd. Koppel dump cars were pushed by hand to deliver concrete to any part of the work. The concrete was dumped from these cars on the trestle through chutes leading down to the point where it was to be deposited. The concrete work was carried on through the winter of 1906-07, some of the most important parts of it, such as the reinforced semi-circular ends of the penstocks, being placed with the temperature below zero. During the prevalence of low temperatures, the water used in mixing the concrete was heated and a jet of live steam was turned into the mixers, with the result that the concrete was delivered hot from the latter, and retained sufficient heat to permit a considerable set to take place before it became cold enough to freeze after it was placed. Live steam was also piped to all parts of the work and was used for thawing ice from the forms and for other purposes. The steam required for this work was furnished by a 60-h.-p. boiler set up in a house near the mixing plant, the motor-driven compressor also being installed in this same house. No salt was used in the water except in a few heavy walls where no reinforcing steel occurred.



An Interior View of the Draft Tubes.

The longer reinforcing rods which required bending were heated in a special forge, adjacent to the blacksmith shop, so they could be bent readily. This forge was a heavy slab of concrete, 6 ft. wide by 15 ft. long and 2 ft. deep, with three longitudinal troughs formed in it. A perforated pipe was buried under the bottom of each of these troughs, and air was supplied from the compressor through these perforated pipes. The long rods of high carbon steel were readily heated in this forge and could be bent to templets without trouble.

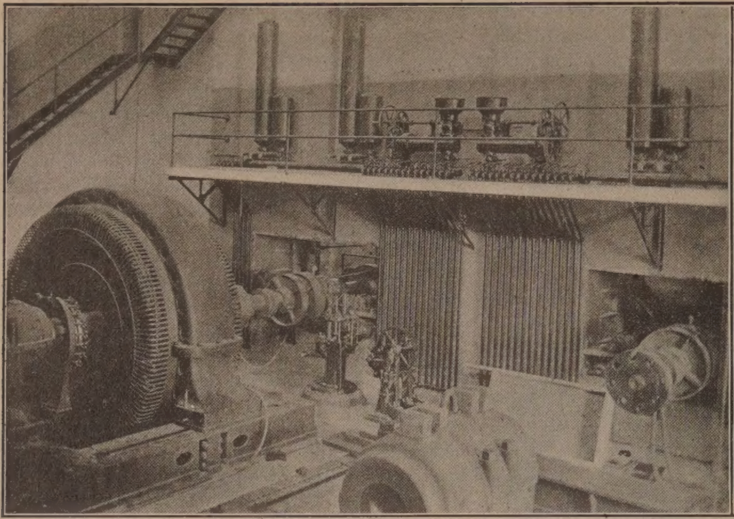
Sluicing Operations and Plant.—After the waste-gate section and power house were practically finished, the river was diverted from its channel between the end of the power house and the high bluff on that side of the valley, and passed through a row of six 7 x 9-ft. openings which had been left in one end of the bottom of the waste-gate section. This diversion was accomplished by rock-filled timber cribs sunk across the channel about 300 ft. above the power house. A low fill of long slope was then made under water on the upstream side of the crib by hydraulically sluicing material into the channel from the high bluff. After this upstream fill had been finished, the channel downstream from the cribs was filled, and the embankment section of the dam was carried up with material sluiced down from the bluff. The temporary closing cribs, when faced with a sluiced fill on the downstream side, were made nearly tight under a head of 15 ft. of water. The water which seeped through and accumulated between the temporary and permanent embankments was removed by a motor-driven 4-in. centrifugal pump running less than a quarter of the time. The possibility of making tight fills with material deposited under water by hydraulic sluicing is thus shown.

In addition to the 104,000 cu. yd. of material deposited in the channel closure and the embankment section of the dam by the hydraulic sluicing process, a fill containing about 20,000 cu. yd. of material, which was required as an approach to a highway bridge just below the dam, was made in the same manner. This highway formerly crossed the river on a bridge about a quarter of a mile upstream from the dam. The temporary approach to the new bridge descends on a 15 per cent. grade toward the river, and is largely a side hill cut, from which the material was obtained to make the fill. This material was carried 100 to 500 ft. and deposited at levels 40 to 50 ft. below the position it occupied in the bank. The latter was all fine yellow sand, which flowed freely on itself when wet.

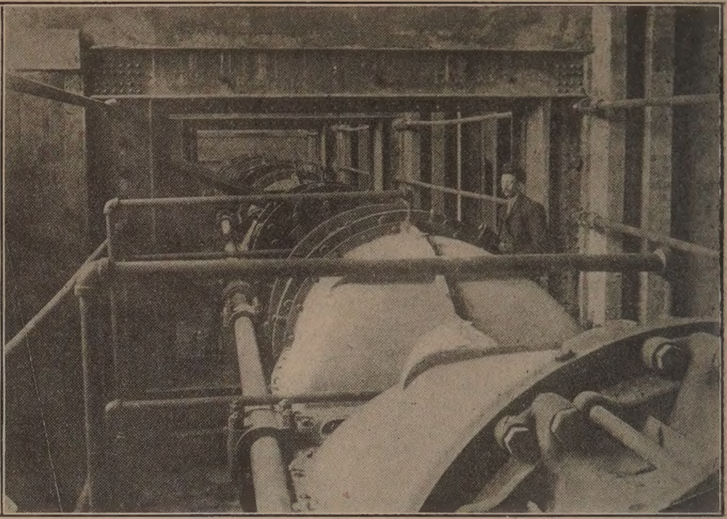
This bridge approach fill was the first one to be made hydraulically in connection with the Croton development, work being started on it in November, 1906. A 3-in. Gould rotary fire pump, driven by a 30-h.-p. motor, was set up on the bank of the river and supplied water for sluicing through a 3-in. pipe line carried up the bluff. A 3-in. hose, carrying a 1¼-in. nozzle, delivered water against the face of the cut from the pipe line. The loosened material was carried down into the fill in a sheet-iron flume, 20 in. wide on the bottom and with vertical sides 5 in. high. This flume was laid on the ground as the cut advanced on the 15 per cent. grade.

The pump and pipe line were set up by two men in two days. With the exception of the labor cost of handling 3,000 cu. yd. of material out of the cut and putting it into the embankment forming the approach to the bridge, no exact records of the cost of making this embankment were made. Four men with the outfit described moved out of the cut and put it into the embankment between Nov. 15 and 20, 1906, the 3,000 cu. yd. of material on which cost data were kept. The four men who did this work each put in 40 hr. at 20 cents an hour, and a foreman was also required for 40 hr. at 25 cents an hour, making a total of $42, or 1.4 cents per yard for labor.

The sluicing outfit used in building the embankment section of the dam included a pumping plant on the bank of the river downstream from the embankment, a pipe line leading from this plant up to, and along the top of the bluff which forms the bank of the river, hose connections from this pipe line to the face of the excavation and flumes leading from the latter down into the embankment. The top of the bluff



Mechanically-Forced Lubricating System for the Water Wheels.



Interior of Penstock Showing Four Pairs of Turbines of a Set.

was yellow sand underlaid at various depths with hardpan and clay. A large percentage of the material in the embankment is sand, however, as under the pressures that were available the hardpan and clay could not be loosened readily enough to sluice.

The pumping plant was comprised of seven Underwriter's rotary fire pumps, one 5-in. Gould, two 3-in. Gould, two 6-in. Gould and two 6-in. Rumsey, all belt-driven by electric motors. Although these pumps were not the most efficient or desirable that might have been obtained for the work to be done, they were used because they were on hand and were readily adapted to be operated by the available motors. While the rotary pumps give good satisfaction for intermittent service of short duration, such as for fire purposes, they are not adapted for the hard, continuous service required in sluicing operations. On this account, an average of 50 per cent. of the pumps were out of order and undergoing repairs the greater part of the time, the breakdowns being for the most part in the gears and cams. For this reason, in future work, of this kind, it is intended to employ either a direct-connected turbine pump, or some other efficient type not subject to frequent breakdowns.

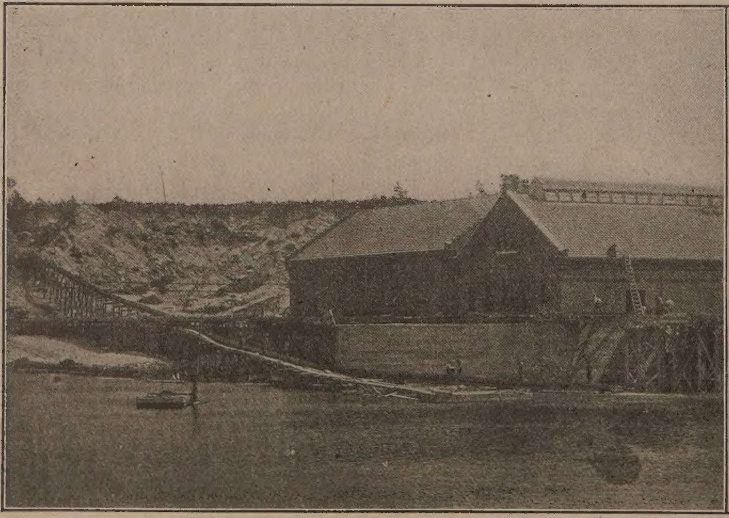
The pumps were placed in a 20 x 24-ft. shed, built on the edge of the river bank so it projected over the bank sufficiently to permit the suction pipes of the pumps to be dropped directly into the water and reduced the suction lift to not more than 8 to 10 ft., as the pumps of this type do not operate satisfactorily at greater lifts. The four 6-in. pumps were set in a row close together and had their discharge pipes connected to a 10-in. header, with the motors on the opposite, or land side of the building. These pumps were designed to run at from 200 to 250 r. p. m.; at the higher speed they should produce a pressure of about 100 lb. at the pump and each deliver 1,125 gal. per minute. In order to run them at this capacity and pressure, assuming their efficiency to be 50 per cent., it would require 140 h.-p.

The first fill above the closing crib across the channel of the river was made with one of the smaller pumps mounted with its motor on a scow. The discharge pipe from this pump was connected by a flexible joint with the force main on land in order that the scow could rise as the pond was filled by the closure of the openings in the crib. The pump used in making the cut and fill on the highway was also set up separately from the main plant.

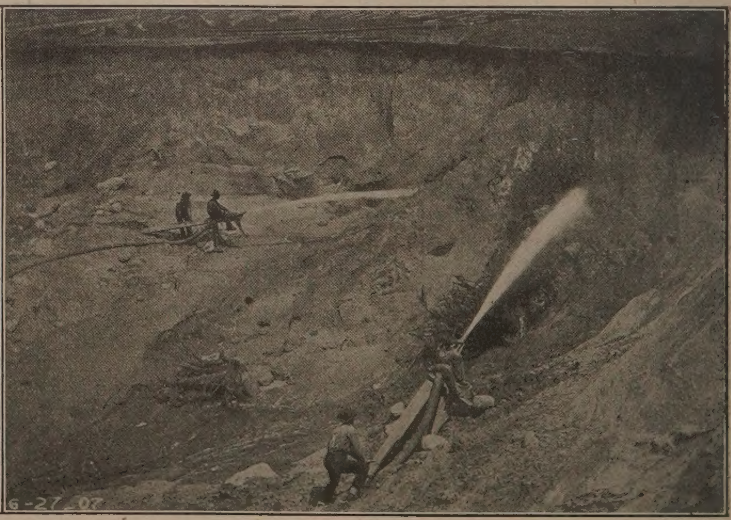
The force main leading from the pumps in the plant set up for the sluicing outfit used in making the embankment section of the dam was a 10-in. spiral-riveted pipe, with a gate valve between each pump connection to this pipe and with one of these valves beyond the last pump. This pipe line was extended along the face of the bluff about 1,000 ft., being reduced successively to 8 in., and then to 6 in. by wrought-iron pipe with screw connections. Tees with 4-in. outlets for laterals and hose connections were placed in the pipe lines at convenient intervals, 4-in. iron body-gate valves being placed at these tees.

The nozzles used at the face of the excavations were mostly for 4-in. hose, and tapered in 24 in. to an opening 1¼ or 1½ in. in diameter. This taper was uniform, the nozzled end being machined and polished inside for about 2 in. from the tip. Each nozzle was clamped to a 2 x 10-in. plank, about 12 ft. long, that was pivoted to a standard similar to the jack used by a wagon-wheel painter, only heavier. This simple device served the purpose of a more heavily-constructed monitor, or giant, such as is generally used for higher pressures and larger pipes and nozzles. With this arrangement, one man handled each nozzle and was assigned a helper who moved the hose and kept the flumes in shape near the nozzle. Where the grades were sufficient, two men for each line of hose were all that were required in the pit. With such an outfit and the pressure at the nozzle 60 to 80 lb., it was impossible to handle any material more compact than sand and gravel; but, with larger nozzle openings and pressure of 150 lb. at the nozzle, hard clay and loose shale rock may be moved readily.

The nozzles were usually worked in pairs, the force of their streams being concentrated at the bottom of the face of the excavation. In places where the sand was underlaid by clay or hardpan, no special headworks were necessary to divert the water and loosened material to the flumes; but, in sandy and gravelly soil, it was necessary to have a converging box, or a series of boards set up in the form of a V to start the flow into the flumes. The water would cut only a slight channel in the pure clay under the sand and gravel, and as these channels did not seem to be deepened by continued use, they



View of High Bank from Which Material was Sluiced.



Two Nozzles in Operation against the Face of a Cut.

were excellent for sluicing purposes. The nozzles were not used for forcing material along the channels or flumes except when the materials became clogged in the latter.

The flumes were for the most part made of No. 12 gauge black iron in 30-in. semi-circular sections, 10 ft. long. These flumes, including the bending, cost 2¾ cents per pound, or 49½ cents per linear foot of flume. In all, 850 ft. of the flumes were required. The sections of the flumes when lapped 6 in. on an 8 per cent. grade, were tight without any calking or fastening whatever at the joint. Wooden flumes were tried, but they were rapidly cut out by the grinding action of the material carried by the water, although after four months' constant use the iron flumes showed but little wear.

The sluicing work was commenced at the distant end of the pipe line, where the first closure of the river channel was made and where the bluff was lowest. The force main could thus be shortened as the work progressed toward the pumping plant. The total height of the bluff above the finished embankment was 75 ft. On account of the grades required for the flumes, however, the actual face against which the streams from the nozzles were directed did not exceed 40 ft., and for the most part was about 30 ft. The greatest distance to which material was moved in the flumes was 800 ft. The flumes were carried on the ground to the edge of the bluff and then to the point where the material was discharged on light pole trestles. They were generally laid on 8 or 9 per cent. grades; but, on some of the longer flumes the grade was reduced toward the end to 5 and 6 per cent. With grades of less than about 6 or 7 per cent., trouble was always caused by stoppages in the flumes, which required one man to about every 50 ft. of flume to prevent. The yellow sand, common to all the pine country of northern Michigan, that was handled in the flumes, will run readily on itself at grades of 10 to 12 per cent. when forced along by the action of water running down a slope.

Table 1. Cost of Placing Material in Embankment Section of Croton Dam by Hydraulic Sluicing Methods.

Cost of Equipment and Materials.	
Two 6-in. Rumsey underwriters rotary fire pumps (new)	$840.00
Two 6-in. Gould underwriters rotary fire pumps (second-hand)	750.00
430 ft. 10-in. No. 16 gauge spiral riveted pipe, cost 60 cents a foot when new, second-hand, 45 cents	193.50
400 ft. 8-in. wrought-iron pipe and fittings (new)	436.45
414 ft. 6-in. wrought-iron pipe and fittings (new) 120 ft. 4-in. wrought-iron pipe and fittings (new)	272.00
Material bought second-hand, including all fittings for the 10-in. line, also 6-in., 8-in. and 10-in. fittings for pumps; 150 ft. 4-in. rubber hose and nozzles; 350 ft. of 30-in. No. 12 gauge flumes used two months on another project	800.00
500 ft. No. 12 gauge 30-in. flume	250.00
Pulleys, belting, 3-in. cotton mill hose and other sundries	200.00
	$3,741.95

Charge 50 per cent. of this total to next job, leaving $1,870.98, to be divided by 104,000, which was total number of cu. yd. of material handled, gives the proportionate cost of plant per cubic yard of material moved, as $0.018.

Items of Labor and Supplies.	
Labor from pay roll, total	$3,774.61
Teams (removing stumps and stone, handling flumes and trestle timber)	248.56
Straw	18.00
Oil, waste, pumps repairs and sundries	118.83
Total	$4,160.00

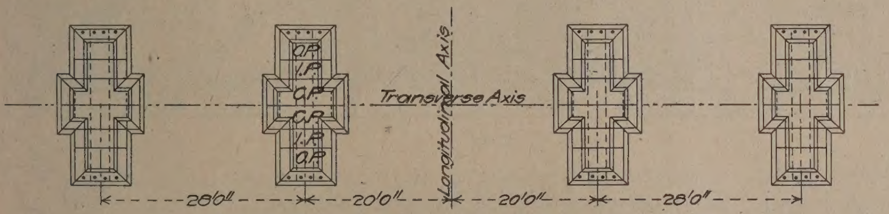
$4,160, divided by 104,000, cu. yd. of material handled, gives 4 cents per cubic yard of material moved, as cost of labor and supplies.

Power.	Kw.-hours.
Power measured at meter at Big Rapids dam, 18 miles from Croton	138,008
Deduct for line and transformer losses and for power used for other purposes at Croton	46,008
Net power used by pumps of sluicing plant	92,000

92,000 kw.-hours at 1 cent = $920.00, which divided by 104,000 equals $0.0088 per cubic yard of material moved.

Recapitulation of Cost per Cubic Yard of Material Moved.	
Cost of plant	$0.018
Labor and supplies	0.04
Power	0.0088
Motor rental	0.0012
Total cost per cubic yard of material moved, as measured in cut	$0.068

As the material was deposited at the end of the flume line it tended to form a cone, with the slope depending on the kind of material. The surface of this cone when made up of sand and gravel, seemed to be drained immediately so that it was possible to walk dry shod over the material while it was being deposited. In order not to completely drain the material as it was being deposited, two lines of flumes were used together in order to keep the center of the fill, low, arrangements being made to remove the water at the farther end. In this way a pool of water and soft material could always be maintained between the two points at which material was being deposited by the flumes. In other cases, the fill was deposited against a temporary dam at the end of the slope in order to prevent the water being drained away too quickly, thus giving the material a chance to settle more compactly by being placed under water. The finished slopes of the embankment at 2 to 1, or 3 to 1, were made by placing boards at the bottom of the slope as the latter was started, and by using straw to prevent the water from undermining these boards. As the work progressed the straw and boards were moved up the slope. Toward the end of the fill where the water to be removed was more concentrated, it became necessary to use brush and a crib work of small poles, 2 or 3 in. in diameter, to retain the soft material at the proper slope.



Location of Main Pier Pedestals of Manhattan Bridge.

The detailed costs of building this embankment by the hydraulic sluicing method are given in the accompanying table, from which it may be seen that the total cost, including all expenses, averaged 6.8 cents per cu. yd. of material delivered into the embankment, as measured in the excavation from which it was removed. This exceedingly low cost of handling material, as compared with other methods, is one of the most favorable features presented in operating a sluicing plant. Mr. W. G. Fargo, under whose direction the work was carried on, states, however, that a plant of this kind is also particularly valuable as a means of moving material from a high to a low level, where it would be very expensive to handle teams on the steep return grade, and that it is quite satisfactory for depositing material in water, such as in filling a pool or a river channel.

(To be continued.)

The Jungfrau Mountain Railroad in Switzerland will be extended from the Mer de Glace to the summit. The extension, including a 2½-mile tunnel, will be 4 miles long.

The Manhattan Bridge Pedestal.

The Manhattan suspension bridge across the East River at New York, between the Williamsburg Bridge and the Brooklyn Bridge, will have, including approaches, a total length of 6,854 ft., and the steel superstructure between anchorages will weigh about 42,000 tons, nearly 19,000 tons of which will be comprised in the 1,470-ft. center span and the two 725-ft. side spans. The center span with a clearance of 135 ft. above mean high tide and the two side spans are double-deck structures 120 ft. wide over all, carrying eight lines of railroad tracks and trolley tracks, two side-walls and one 35-ft. roadway, and are proportioned for a regular live load of 8,000 lb. per lineal foot or a congested live load of 16,000 lb. per lineal foot. They are stiffened with two lines of riveted trusses 24 ft. deep, which are suspended at panel points about 18 ft. apart by four 1¾-in. steel suspender ropes from four main cables 21 3/16 in. in diameter, each composed of 9,472 parallel galvanized wires .192 in. in diameter. The cables are supported on massive cast steel saddles bolted, with 28 2-in. bolts, on top of vertical towers 281.89 ft. high.

Each tower consists of a single transverse bent with four vertical posts rigidly connected to the pier masonry and intended to spring 8 in. in either direction from the center line at the top parallel to the bridge axis with variations of temperature and loading. Each tower weighs about 12,500,000 lb., and each post is made in 14 lengths, each of which is shipped from the bridge shop in two or more pieces of 64 tons maximum weight. Each post has a closed rectangular cross section with 4 interior webs perpendicular to the bridge axis. The dimensions vary from 5 x 10 ft. at the top to 12½ x 33 ft. at the base, where it is seated on a riveted steel sectional pedestal 42 ft. 4 in. long, 21 ft. 10 in. wide and 5 ft. 5 in. high over all, which weighs 190 tons.

It was originally intended to make each of the eight pedestals of cast steel weighing about 380,000 lbs., and composed of six sections bolted together through vertical transverse webs. Owing to the difficulty and delay likely to be experienced in securing and finishing steel castings of these dimensions and shapes it was decided to substitute riveted steel for cast steel in the pedestals which were, however, to retain their original outline and dimensions. They were accordingly redesigned to have about the same weight and corresponding details to those of the castings and have been made by the Bridge Co., for the same pound price as was allowed for the original design.

The pedestal is proportioned to distribute uniformly over 695 sq. ft. of the surface of the pier masonry a maximum vertical load of 20,580,000 lb. produced by the congested live load of 16,000 lb. per lineal foot over the full length of the bridge. The maximum stress in the outer edge of the pedestal is produced when one-half of the main span and one of the side spans is entirely covered by the congested load and the remainder of the bridge is entirely unloaded. This corresponds to a possible deflection of 2 ft. at the top of the tower and although it is not considered probable that this will ever occur, the pedestals are designed to resist the extreme stresses.

The reaction of the masonry under one edge of the pedestal is a maximum of 64,000 lb. per square foot and the corresponding up-lift on the opposite edge may reach 9,000 lb. per square foot, equal to a total up-lift of 334,000 lb. In designing the pedestal it was at first arbitrarily divided into six sections for convenience of manufacture and shipment. The joints between them being located so as to most advantageously receive and transmit the stresses. The general outlines were adapted to cast steel construction and to conform with the architectural requirements.

The pedestal is finished on the upper and lower surfaces and on the abutting faces and the different sections are joined together by large horizontal bolts through their vertical webs. Section No. 1 has a maximum vertical load of 6,900,000 lb., which at an assumed coefficient of friction of 25 per cent. will develop 1,725,000 lb. friction with its base plate. The horizontal component of the maximum bending moment in the post produces a total horizontal stress of 3,700,000 lb. at the base of the pedestal.

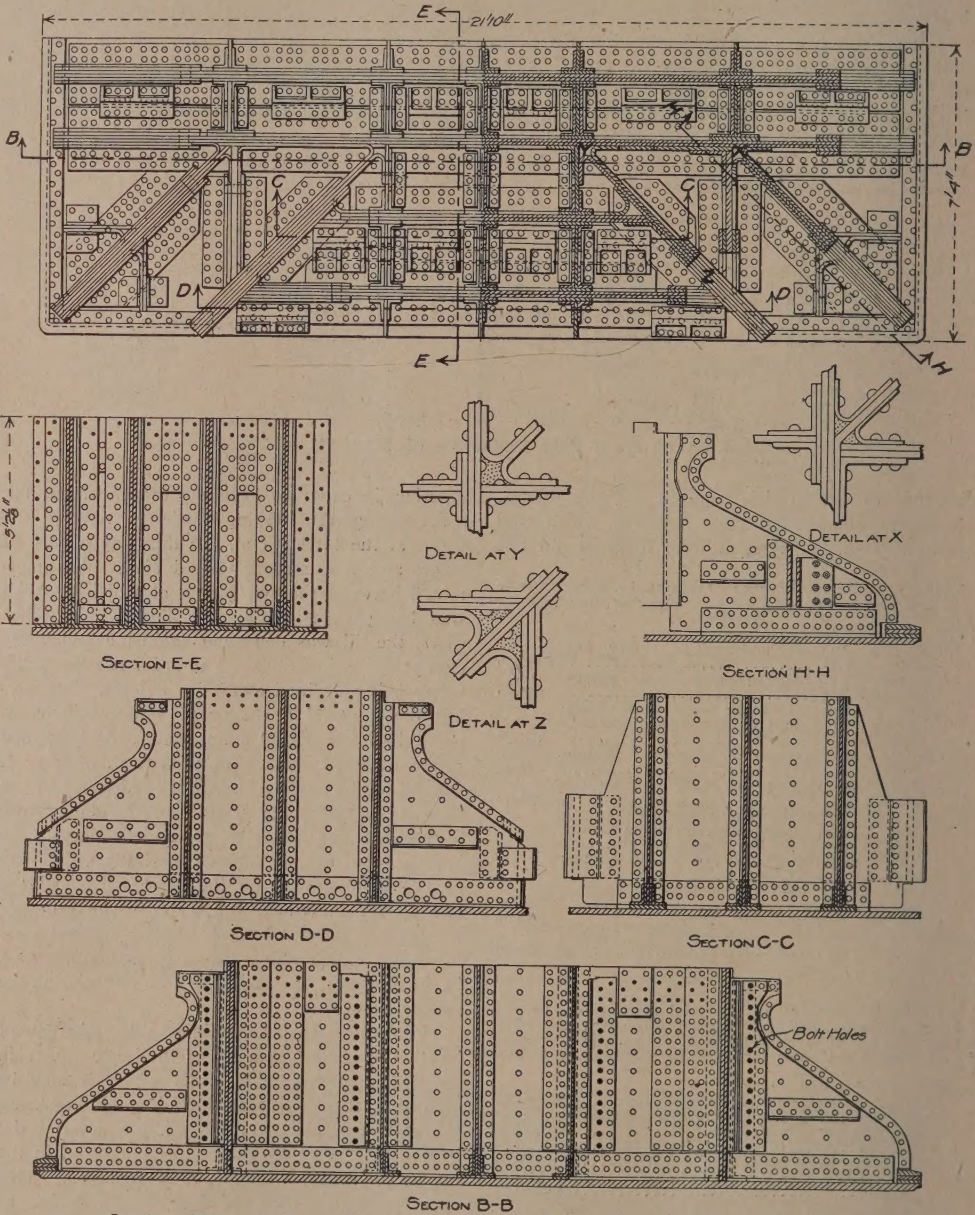
In order to prevent the possibility of transmission of this stress to the masonry and consequent tendency to rupture the latter, the pedestal is seated on a bed plate made with three full-length longitudinal rolled steel plates 56 in. wide and planed on one side from a thickness of 1⅛ to ⅞ in. These plates are seated directly on the accurately dressed upper surface of the pier masonry to which they are connected only by eight 2¾-in. anchor bolts coarse-threaded their entire length and grouted in 4-in. holes 11 ft. deep in the pier masonry. These anchor bolts also pass through the base plates of the pedestals and the nuts at their upper ends engage saddle plates on riveted distributing members attached to the pedestal webs. Except for these bolts there is no connection or splicing between the pedestals and the base plates. Under maximum loading the bed plates act as outside splices to the base of the pedestal section developing the tensile strength above mentioned of 1,725,000 lb., which subtracted from the total horizontal stress, leaves a remainder of 1,975,000 lb., which is provided for by the eighteen 2½-in. flange bolts.

The pedestal was designed with its main ribs in the planes of the post webs and virtually forming continuations of them with faced butt joints and splices generally made with double field riveted or field bolted cover plates. In addition to these webs there are provided exterior transverse longitudinal and diagonal webs or extensions to distribute the load over the entire horizontal surface of the wide long base plate. In all cases the connections of the pedestal webs to the webs of the posts were designed to take their proportionate share of the maximum post loads.

In the two end sections of the pedestal the ribs parallel to the bridge axis are made with continuous full-length webs and were treated in design and computation as simple T-shaped girders with flanges made by the sole plate. The intersecting ribs were made in short sections at right angles to and web-connected with these and are cantilevered beyond their outer faces. The tension in them is designed to be entirely taken up by the sole plate and the compression by the bearing on the web connection.

The diagonal ribs are made up with four web plates, 2 of which extend for a long distance parallel to the longitudinal ribs, riveted integral with them. The other two web plates are bent short to form oblique web connection angles. The rivets are proportioned to provide for all vertical shear and horizontal stress due to the maximum bending in the post. It was arbitrarily assumed that all rivets resisting bending stress were located within 12 in. of the tops of the ribs and it was assumed that the vertical stress is resisted by the remaining rivets in the whole area of the webs. By these assumptions the resultant stress in the upper rivets is reduced to a minimum of ordinary unit value. The remainder of the rivets, of course, receiving low unit stresses.

All of the ribs in the outer edges of the first section of the pedestal are calculated by the methods used for reinforced concrete beams, assuming that all tension is carried through the base plate and that the compression is received by the remainder of the cross sectional area of the member. All rivets are 1 in. in diameter and all rivet holes are drilled from the solid without punching. All spaces between the pedestal ribs will be filled solid with concrete extending up to the man-holes in the post webs. In order to relieve as much as possible the stress on the pedestal base plate and to assist in the distribution of stresses, horizontal angles are riveted to the faces of the webs with their horizontal flanges projecting into and embedded in the concrete.



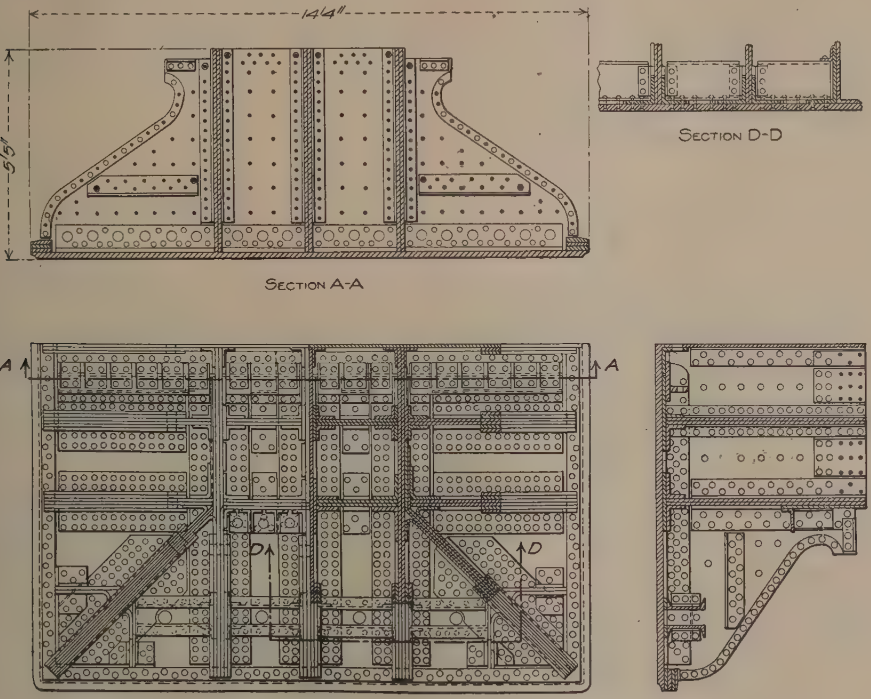
Center Piece C. P. of Manhattan Bridge Pedestals, Weight 41 Tons.

The pedestal has no regular cap plate and the foot of the vertical post has no horizontal base plate. The spaces between the ribs are therefore unobstructed to give clearance for the vertical cover plate, splicing the post webs and pedestal ribs together. The upper edges of the pedestal ribs are, however, connected around the outside by a horizontal cornice of incomplete I-shape cross section made with a 15x2¼-in. horizontal web, one 7 x 5 x ¾ in., one 6 x 6 x 1 in., and one 8 x 6 x 1 in. flange angles as indicated in the cross sectional details. The web plate is bevelled for drainage on the upper face where the heads of the flange rivets are countersunk. It is made in sections up to 14 ft. long with mitered joints and is riveted to special flange connection angles on the upper edges of the pedestal ribs, which are notched to receive it.

Each pedestal is divided into six sections by vertical joints transverse to the bridge axis as indicated in the general location diagram which also gives the position of the anchor bolts and shows the cornice and a corresponding stiffener rim around the base plate. The end, intermediate and center sections of each pedestal are symmetrical about its center line transverse to the bridge axis and have respective weights of 31, 19 and 41 tons. The center section has an 80-in. x 2-in. base plate 21 ft. 10 in. long and has in all 24 web plates from ⅝ of an inch. to 1 in. in thickness and 53 in. in maximum width which are riveted together in sets of 2 or 3 to form the rim. The flange angles are chiefly 8 x 8 x ⅞ in. The curved and inclined outer edges of the ribs are reinforced with double pairs of 3 x 1 in. flats and the spaces between the bent web connection angles and the ribs are filled solid with slow setting iron rust cement.

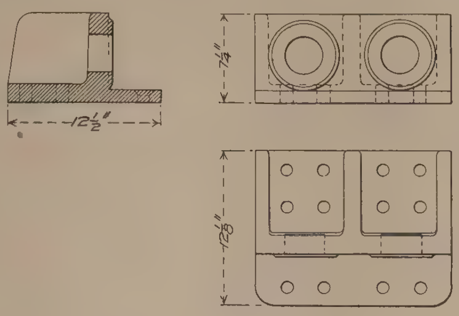
The intermediate section of the pedestal has a 59 x 2-in. x 14-ft. 4-in. base plate and is of comparatively simple and regular construction as indicated in the general assembled diagram. The end section of the pedestal is of complicated construction and has a 107 x 2-in. x 14-ft. 4-in. base plate with web plates 1 in. and ¾ in. thick riveted together in pairs to form the ribs except for the few horizontal bolts connecting the vertical webs of adjacent sections of the pedestal which have nuts taking bearing on the faced surfaces of cast steel blocks riveted to the base plates of the pedestals. The blocks are made for 2, 3 or 6 bolts each, and all of them have unsymmetrical T-shaped cross sections stiffened by transverse webs dividing it into pockets for each bolt. They weigh from 145 to 475 lb. each.

The tower piers have long been finished and the anchorage piers are nearing completion, the 4,948,000 lb. of structural steel in them having already been delivered and set. The fabrication of the remainder of the super-structure has been in progress for several months at the bridge shop and when the erection was commenced in July, 12,887,000 lb. of steel for the towers and 3,770,000 lb. of steel for the pedestals had been delivered to the shops and 2,040,000 lb. of finished tower and pedestal sections had been delivered to the storage yards at Bergen Point, whence it is forwarded daily as required for erection in the super-structure which it is expected will continue simultaneously at both main piers. All of the pedestals have now been completed at the shops and erected. The separate sections were delivered by barges and unloaded by a floating derrick which places them on top of the masonry where they were rolled to position and set by hydraulic jacks.



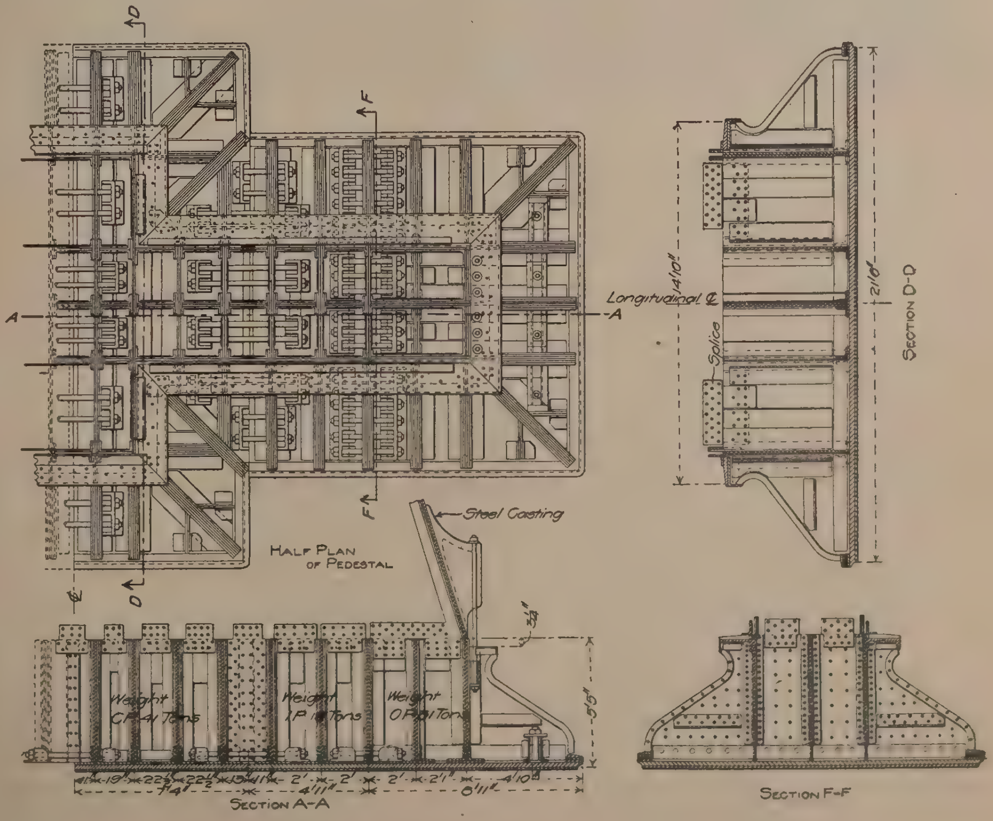
Outside Piece O. P. of Manhattan Bridge Pedestals, Weight 31 Tons.

The cables are supported over the towers by eight cast steel saddles 11 ft. long 5 ft. 11 in. wide and 3 ft. 4½ in. high over the anchorage on eight sectional cast steel saddles, which are 30 ft. long, 5 ft. wide and 4 ft. high, seated on 60 segmental cast-iron rollers 9 in. in diameter. The saddles, rollers and 4-in. thick bed plates have to be planed, besides which there are 2,500 cast steel cable bands 3 ft. long made with flanged halves bored to a diameter of 21 3/16 in., 2,500 suspender sockets and as many 5-in. cast steel nuts, each weighing 50 lb., and all requiring to be faced or threaded or both. This makes an aggregate of about 2,000,000 lbs. of steel castings with single pieces weighing up to 31,000 lb., and involving a large amount of machine work. The contractors found that although it was comparatively easy to place the orders for the castings there was great difficulty in securing any promises to finish them within a reasonable time and that very high prices were demanded for the machine work. As the contractors already possessed a 50 x 150-ft. convenient and well-lighted machine and repair shop at their Crotch Island quarry in Maine, which was well equipped with steam, pneumatic and electric power, and with abundant ordinary tools, they decided to install there some special machine tools and finish all the castings themselves. They have accordingly purchased from Manning, Maxwell & Moore a 10 x 7 x 18-ft. Betts Machinery Company's planer and a 120-in. horizontal boring mill of the same make, a Dressers' radial drill, a large Cincinnati railroad shaping machine, a 22-in. Reed lathe, and a very heavy combination bolt machine for cutting threads on the 5¼-in. suspender sockets and tapping the nuts and a horizontal emery wheel grinder for spot facing small bearings. These tools have already been installed at the shops and the castings will be shipped to and from the shops by schooner at a freight cost of from 80 cents to $1.00 a ton for each 450-mile trip between the shops and New York City. Careful estimates indicate that a saving of at least $25,000 will be made on the cost of finishing the steel casting besides the great advantage of having the work under the direct control of the contractors and avoiding unnecessary delays and uncertainties.



Casting for Splice Bolt.

Several plans have been devised for handling the work in such a manner as to expedite it and greatly economize the cost. Instead of boring the cable bands they will be clamped concave side up, in sets of 10 on the table of the planing machine and they will be dressed by high-speed steel tools with segmental cutting edges set to the exact radius and revolved transversely by a worm gear enabling them to finish the entire cylindrical surface with single cuts, moving at the rate of 22 ft. per minute and taking a chip about ¾ in. wide. The bands will be arranged in two parallel rows on the planer bed and while the concave surface is being finished, side tools will plane one set of lugs after which they will be reversed and the other set planed. A similar device will be used for planing the segmental surfaces of the 480 rollers. Twenty patterns have been made from the 2,500 suspender sockets and they will be finished after the cable saddles and rollers are completed. Over 300 tons of castings are now at the shops from whence the first finished lot has already been shipped back to New York.



Half of Assembled Pedestal; Weight of One-half 90 Tons.

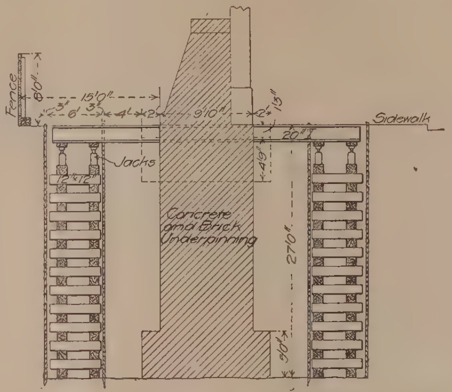
The bridge is designed and constructed under the direction of the Department of Bridges, New York City, Mr. James W. Stevenson, commissioner, Mr. O. F. Nichols, consulting engineer, and Mr. A. Perry, assistant engineer, in charge of design. The Ryan-Parker Construction Co. is the general contractor, the riveted super-structure is fabricated by the Phoenix Bridge Company and erected by the Terry & Tench Construction Co. The cables will be manufactured and erected by the Carbon Steel Co., Mr. Holton Robinson, chief engineer.

Water Purification at McKeesport.

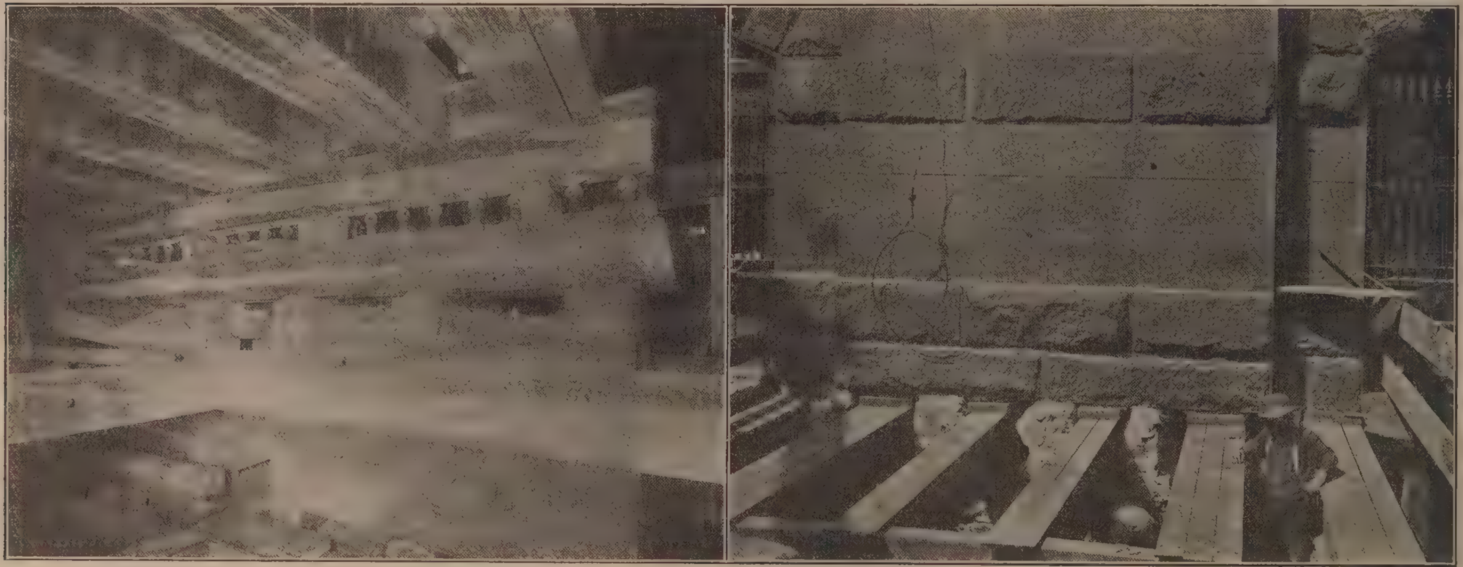
The water purification works now under construction at McKeesport, Pa., are unusual on account of the necessity of softening as well as filtering the supply. The water is drawn from the Youghiogheny River, with a small additional amount from driven wells. Both river and well water contain a large amount of sulphates of lime and magnesia, requiring the use of caustic lime and soda ash, the former neutralizing the carbonic and sulphuric acid and the latter reducing the natural hardness and that added by the caustic lime. The plant has a nominal capacity of 10,000,000 gal. per day. It is a circular building 177 ft. in diameter in the basement, 92 ft. on the ground floor and 64 ft. on the second floor. The water is divided when it enters the plant, a large part flowing directly on its way, while a smaller part passes through lime saturators. This saturated solution is then mixed with the raw water in a channel leading to the mixing tanks, and the passage of the mixture through these tanks completes this part of the process. The water then flows to settling tanks where it is clarified, the stay of the water in the mixing and settling tanks being varied according to the character of the mineral matter. The various tanks and channels are arranged in a circular manner, the inner one being a waste channel from the filters and softening plant, the next one the channel for conveying water from the lime-saturating tanks to the mixing tanks, the next one being the mixing tanks themselves, the next one the channel for conveying water from the mixing tanks to the settling tanks, and outside of all the settling tanks. Outside of the settling tanks is a channel which carries the softened water to the mechanical filter plant containing six beds of 1,000,000 gal. capacity each. The plant was designed by Mr. Alexander Potter, and is being constructed under his supervision, all portions of it being of reinforced concrete.

Underpinning a 400-Ton Piet.

The portion of the double-track subway of the Philadelphia Rapid Transit Ry. located in City Hall Square, is very near the Pennsylvania R. R. Terminal Station, where the excavation was carried through sand and gravel to a depth of about 30 ft. adjacent to one of the piers supporting the train floor and side roof of the depot and estimated to carry a total load of about 400 tons on its 14 x 20-ft. base. The pier was of brick and granite above the surface of the ground and had a rubble footing about 9 ft. deep, seated in the dry earth.



Method of Underpinning Pier.



Needlebeams through Pier Footing and Jacks Used in Underpinning a 400-Ton Pier.

A sheeted trench was excavated to 6 in. below subway grade on both sides of the pier and from it tunnels were cut through the footing wide enough to receive six groups of transverse I-beam needles and still leave sufficient rubble between them to support the load until it was transferred to the needles. Each needle beam consisted of two or three 20-in. 70-lb. I-beams, 26 ft. long, 16 in all. On the inside of the building the needle beams were supported on longitudinal sills on cribbing in the trench, 12 ft. on centers from the pier. The crib footings had a sufficient area to reduce the pressure on the surface of the ground to about 6,000 lb. per square foot. The opposite ends of the needle beams projected correspondingly about 12 ft. beyond the front of the wall and were seated on a 12x16-in. longitudinal sill supported by a similar cribbing.

About 20 jack screws were set under the sills at each end of the needle beams and were simultaneously operated to transfer the weight of the pier to the cribbing without perceptibly raising the pier. Alternate spaces left between the jack screws were filled with blocking on which pairs of wedges were driven as fast as the screws were operated so as to take up all slack and provide solid bearing competent to carry all the load and prevent any vertical movement should the jack screws fail under stress.

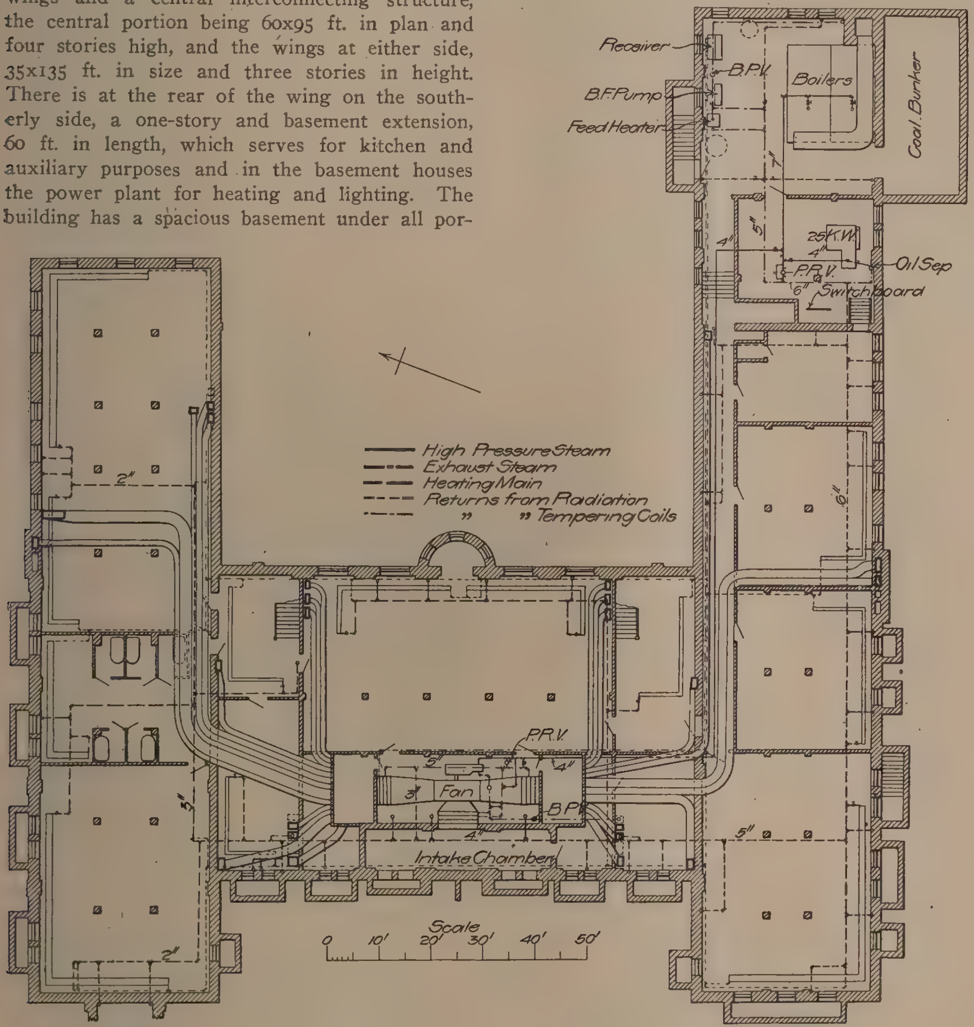
Excavation under the needle beams was carried down between the cribs to sub-grade and a new concrete foundation for the pier was built there clear of the needle beam supports and was carried up nearly to the lower flanges of the needle beams. Brick piers were built up between the needle beams nearly to the base of the masonry pier and engaged it in the usual manner with pairs of capstones separated by steel wedges and grouted in position. After their completion the jack screws were slacked off, releasing the needle beams, which were removed and the spaces they had occupied were filled with brickwork built up as here described. The new foundations contained about 90 yd. of concrete and together with the needling was built in about 22 days by an average force of 17 men.

The work was executed by Henry Sheeler & Sons, Chicago, as subcontractors to the E. E. Smith Contracting Co., general contractors for the City Hall section of the subway. The plans and operation were under the approval and supervision of the Philadelphia Rapid Transit Railway Co., Mr. W. S. Twining, chief engineer; Mr. Charles M. Mills, principal assistant engineer, and Mr. Frank R. Fisher, resident engineer.

Coal Mining in Illinois during 1906 produced 41,180,100 short tons, or 7.9 per cent. more than in 1905, ranking second only to West Virginia. In anticipation of the suspension of operations which took place on April 1 the Illinois mines were operated to their fullest capacity for several months prior to that date, and the shortage due to the suspension was, to a great extent, provided for. After operations were resumed in June the intensity of labor among the mine workers was considerably greater than usual. This is shown by the fact that the average daily output per man was 3.13 tons in 1904, 3.29 in 1905 and 3.49 in 1906. According to the U. S. Geological Survey, a large part of the increased efficiency in labor was probably due to a greater use of machines for undercutting coal. In 1906 there were in use in the coal mines of Illinois 1,048 machines, and the machine mined product was 11,585,419 short tons, against 882 machines and a machine-mined product of 8,697,547 tons in 1905, and 643 machines and 7,110,902 tons in 1904.

Heating System of the St. Francis Home, Detroit, Mich.

The St. Francis Home for Orphan Boys is an orphan asylum that is being built near Detroit, Mich., by a Catholic organization of that city as a memorial to Bishop John S. Foley. It is located in a district known as Highland Park, about one mile beyond the northern city limits on Woodward Ave., where a large tract of land was secured for the grounds. An imposing structure of considerable size has been built of brick wall-bearing construction, with hollow-tile floors on steel beams and tile roofs, which provides dormitory and educational facilities for 300 orphans and the requisite number of teachers and attendants. The building has two side wings and a central interconnecting structure, the central portion being 60x95 ft. in plan and four stories high, and the wings at either side, 35x135 ft. in size and three stories in height. There is at the rear of the wing on the southerly side, a one-story and basement extension, 60 ft. in length, which serves for kitchen and auxiliary purposes and in the basement houses the power plant for heating and lighting. The building has a spacious basement under all portions, the first floor being from 3 to 4 ft. above grade, and there are attic spaces over both of the side wings.



Mechanical Plant in Basement of St. Francis Home, Detroit, Mich.

The building occupies a particularly exposed location and has large areas of wall and window glass exposure, so that the problem of heating was one of considerable magnitude. In addition, ventilation is necessary in the greater part of the building owing to the number of dormitories, school rooms and other public rooms which will be occupied by large numbers of persons. Accordingly a scheme of heating arrangement was chosen which combines hot blast heating for all of the pubic parts and rooms which will, at times, be extensively occupied, such as the dormitories, the large dining-room, the chapel, etc., and direct radiation for the heating of all smaller rooms and for auxiliary heating in the larger public rooms. A feature of the installation is the use of hot blast heating in the dormitories to the entire exclusion of direct radiation, this being particularly feasible as the ventilation is essential at night when the large numbers of beds in them are occupied and, as the rooms are not occupied in the day time, no heating is required except at night time; the heating requirements are similar to these in the school rooms, no heating being required when they are not occupied, and they are accordingly fitted for indirect hot blast heating only, there being, in fact, no direct radiation above the second floor in the south wing and above the first floor in the remainder of the building, excepting in the toilet rooms in the central portion.

The heating installation is accordingly a simple one, insofar as direct radiation is concerned, there being but two radiators each on the third and fourth floors while the radiation on the lower floors is comparatively small in amount, excepting on the second floor of the south wing where a number of smaller rooms are individually heated. The total amount of direct radiation installed in the building is 4,450 sq. ft., comprising 3,600 sq. ft. in cast-iron radiation and 850 sq. ft. in pipe coils, while the total heating surface for the hot blast systems amounts to about 6,800 lineal feet of 1 in. wrought iron pipe. The distribution of the direct radiators is such that the greater part of those on the first floor and all surface in the basement, which consists of ceiling pipe coils, are supplied by convenient connections from the ceiling steam distribution mains in the basement, while the radiation on the second floor is supplied by 17 risers that are of comparatively small size and rise to the second floor level only, excepting two that supply toilet-room radiators of the two upper floors. The direct radiators, where depended on solely for the heating of the smaller individual rooms, are proportioned to counteract the heat loss from walls and windows upon the usual thermal unit basis, and are placed in the usual arrangements under window sills in all cases. They are of the Rococo and Perfection types of cast-iron radiation built by the American Radiator Co., and are fitted with Crane Co. supply valves and Monash air valves, which connect to a system of drain piping leading to the basement. The pipe coil surface for heating the basement rooms comprises a total of 1,700 lineal feet of 1½-in. wrought-iron pipe, which is distributed in 14 sections of sizes from 75 to 250 lineal feet each. These units are distributed along the outer wall lines of the basement rooms near the windows which rise to the ceiling line and are proportioned with regard to the rooms heated on the thermal unit basis similar to the other radiation.

The heating, both direct and indirect, is operated with low-pressure steam supplied partially from the exhaust of the steam-using machinery of the power equipment of the building, with provisions for supplementary live steam supply from the high-pressure system, when necessary, The steam-using machinery installed at the building consists of a 25-kw. electrical generating unit and two pumps for boiler feeding and condensation return purposes which are located in the power plant at the rear of the south wing and the engine driving the fresh air supply fan in the front portion of the basement. These units are all connected to a common exhaust main in the ceiling of the basement which serves as the source of heating supply for both direct and indirect radiation, relief to the atmosphere being provided by a 5-in. extension from the boiler room end of the main, through a back pressure valve, to an exhaust head above the roof of the power plant extension and through a 3-in. extension of the fan room division of the main similarly through a back pressure valve to a roof exhaust head. The three groups of machinery deliver steam into the main through oil separators to keep the heating system free from lubricating oil, that in the fan engine exhaust being a 4-in. separator while 5 and 3-in. separators are used in the generator engine and pump connections. This exhaust main is a 6-in. line throughout the basement of the east wing to the point of connection with the generator engine and reducing valve for live steam supplementary supply, beyond which it extends as a 5-in. line to connect with the boiler feed water heater, the pumps and thence to the atmospheric relief connections; near the front a 5-in. branch extends from the main across to the north wing of the building through which connection is made to the fan engine division of the system. The latter connection is, however, but 3 in. in size, as it is calculated that the fan engine will always, when running, supply all or nearly all of the steam that will be needed for the indirect heating coils and the 3-in. connection is intended principally for supplementary supply. This fan room main is a 5-in. line into which the 3-in. delivery connection and the 4-in. engine exhaust delivers, and there are also live steam supplementary connections at this point also for additional heating capacity if required.

The direct radiation is, owing to the short length of the supply risers, operated on the one-pipe system with a system of returns by gravity from a number of points in the supply main. The risers supply but 1 or 2 units on each floor level, and, owing to the comparatively small amount of surface required, are of but 1½ and 2-in. pipe for the 15 risers that are carried to the second floor level; only two of the risers, which are carried up to supply toilet-room radiation on the third and fourth floors, are of 2½-in. pipe. The connections from the risers into the supply mains are made for the greater part at an angle of 45 deg., with ample provisions for expansion of the main and connections, and the risers are firmly anchored to the steel work of the building by clamps near their bases permitting expansion in an upward direction. In most cases the risers are run concealed in recesses or chases provided for them, and the radiation branch connections are run exposed above the floor except where the distance between the riser and the radiator is such that sufficient drop is not available above the floor, when the connection is made on the ceiling of the floor below. These connections are so arranged that there is a pitch between the radiator and the riser connection of at least ¼ in. per foot when the riser is hot and expanded, and the branch connections are so made that the riser may freely expand without moving the radiator. With this system of returns the risers drain directly into the steam supply main which is pitched in the direction of the flow of the steam and is drained at convenient points and at the ends, through hydro-static seals to the return main; these seals are return or U-pipe connections, 6 ft. in length, in which the condensation accumulates and prevents direct steam communication from the heating supply main to the return main; these seal pipes are fitted with flanges so that they may be readily disconnected for inspection and cleaning and also have drain cocks for drawing off the condensation accumulated. In addition to these at the ends of the mains and all branches there are similar water seals at the basis of all risers which are more than 20 ft. from the connection to the supply main so that drainage to the latter would be difficult, and all of the ceiling pipe coil heating surfaces in the basement are similarly drained to the return main.

The condensation from the direct radiation is, as above stated, returned to the boiler-room by gravity, a 3-in. return line being carried on the floor of the basement to all parts of the building paralleling the steam supply mains. Into this all of the drainage seals of the direct radiation system are connected, the heating coils of the indirect systems being connected into an independent return line with discharges through steam traps to permit of the use of high pressure steam in the coils if necessary. This return line from the direct radiation has a full size extension from its receiver tank end to connections with the two boiler units of the plant, permitting the direct radiation to be operated with the gravity return whenever the fan apparatus, the pumps and other high pressure machinery are not in use. The radiator air valves connect through ¼-in. lines to ½-in. risers paralleling the steam supply risers and the air risers in turn connect into a system of ¾-in. air mains in the basement which extends to the catch basin to discharge any water of condensation that may pass the air valve. All of the heating piping, both for steam supply and return, is covered with 85 per cent. magnesia sectional covering, canvas jacketed and banded, which ranges from ⅞ in. in thickness on the smallest pipes to 1½ in. on the larger pipes.

The indirect heating system is operated by a single large blower unit which is located in a 14x48 ft. room in the front portion of the basement, having a fresh air intake through the space under the porch of the front entrance and deliveries connected to numerous galvanized iron ducts leading into brick flues rising to the upper floors. The blower is a ¾-housed double-discharge steel plate fan of the centrifugal type, built by the American Blower Co., which is designed for a delivery of 22,400 cu. ft. of air per minute with a speed of the wheel of 200 r. p. m. The wheel is 7 ft. in diameter by 4 ft. in width, and is directly connected at one end with a simple vertical steam engine of the enclosed self-oiling type which was supplied also by the company building the fan. This engine has a 10x12-in. cylinder and is designed to operate the fan to its maximum capacity with steam at an initial pressure of 35 lb., and exhausting against a back pressure of 5 lb. per square inch, it being the intention to utilize the exhaust from this engine in the indirect heating coils at all times during the heating season when the fan is operated. Steam is supplied to the engine by a 4-in. line extended from the high pressure header in the boiler-room to the fan room where it has connections to the heating coils and a 3½-in. branch with steam separator to the engine throttle valve.

The fan has its intake through an 8x36-ft. space under the front entrance porch of the building which space may also serve to accomodate an air filter, if air filtration should at any later time prove necessary. Into this chamber two windows open from the outside, having free areas of about 20 sq. ft. each, and they are fitted with tight closing sash which may be shut in case it is desired to close down the fan system in cold weather. In the connection from this chamber to the fan casing, there is installed a tempering coil containing 2,250 lin. ft. of 1-in. pipe, which is disposed in three 4-row sections, in order to facilitate the adjustment of the surface to the heating requirements. The fan discharges through an arrangement of two plenum chambers, one at either end of the fan room from which the delivery ducts to either side wing of the building are supplied, a connection from each of the two horizontal discharge outlets of the fan leading to one of the plenum chambers with an enlargement of the casing near the latter containing a reheating coil. These reheating coils each contain two 5-row sections of 1-in. pipe having a total amount of surface equal to that of the tempering coil, the arrangement of pipes in these heaters as well as also in the tempering coil being such that a free passage for air between pipes 1½ times that of the cross-sectional area of the duct connections is secured. Air mostening connections are installed in each of the plenum chambers, consisting of ½-in. pipes, 10 ft. long, which are drilled with large numbers of 1-32-in. holes and connect with the low-pressure steam mains for delivery of vapor to the hot air blast.

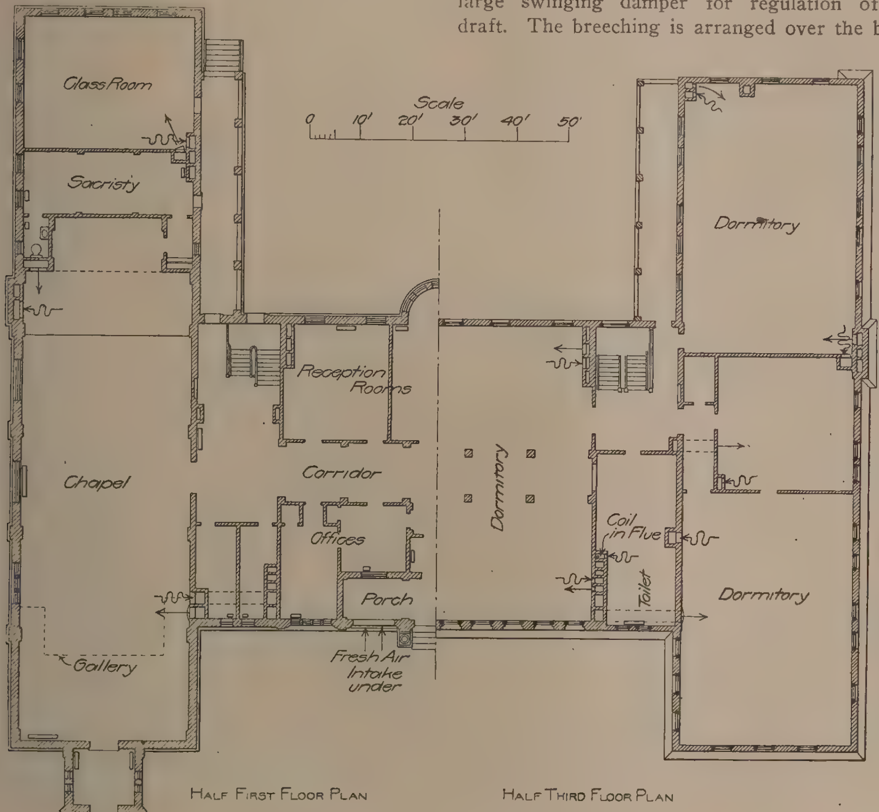
Each of the three heating coils have two Monash air valves to prevent air binding, and they are, as above stated, supplied with steam from the exhaust steam system with returns independent from those of the direct radiation in order to permit of their operation with high pressure steam if required. The exhaust steam from the fan engine will always be utilized in the heating coils in cold weather, the fan engine exhausting through a 4-in. line with oil separator into a 5-in. low-pressure receiver-header in the fan room, into which is also connected a 3-in. branch from the low-pressure heating main from the power plant for purposes of reserve supply. This header has 3-in. branches to all of the heating coils and has in addition three 2-in. connections from the high-pressure steam main for live steam supplementary supply if required; two of these high-pressure connections lead direct to the header, one through a 3x6-in. reducing valve for low-pressure supplementary supply, and the other a by-pass direct, while the third is carried beyond and connects into the branch which feeds the tempering coil, this arrangement being made to permit of delivering high-pressure steam to the tempering coil independent of the supply to other coils. These heater coils have a separate system for condensation return to the receiving tank in the boiler room consisting of a 2½-in. line into which each of the coils discharge through a 2-in. Morehead trap. This permits an extra pressure to be carried on any or all of the heating coils without interference with the low-pressure direct radiation system.

The plenum chambers are 8x12-ft. air-tight enclosures partitioned off in either end of the fan room, from the outer walls of which the air delivery duct connections are made. Of these there are 11 originating in the south chamber to supply rooms in the south wing and 13 from the north chamber to supply the north wing, making 24 delivery ducts in all. The chambers are built of 9-in. brick walls which are carried up to within 4 in. of the basement ceiling and there covered with tops of No. 16 black iron stiffened with angles. Each of the chambers has also a horizontal partition or diaphragm at a level of the base of the heater coil, the upper portion for the heated air from the reheating coils, and the lower portion for tempered air direct from the fan, suitable mixtures of the two being obtained by dampered openings in the diaphragms. The delivery ducts are for convenience of erection installed of a uniform depth of 20 in. for all widths, securing thus a uniform head-room throughout all portions of the basement, and range in width from 10 to 24 in., according to the capacity. Six of them are 10-in. width, 10 of them 12-in., 2 each 14, 16 and 18 in. in width and one each 20 and 24 in. wide. The ducts are all built of No. 24 galvanized iron, thoroughly braced and they are all laid out with easy bends of long inside radius, ending in a sweep sheets in the form of one-quarter circles at the bases of the masonry flues through which delivery is made to the upper floors; these sweep sheets are of No. 16 galvanized iron extending the full width of the flue with flanges securely driven into the joints. Every duct connecting with either of the plenum chambers is fitted with an air gate or damper by means of which the connection can be entirely closed off when the room supplied is not in use, the gate consisting of a No. 18 galvanized iron diaphragm so pivoted and mounted that it can be set for one-third opening, one-half opening or other adjustment as desired.

Ventilation is applied to all rooms on the downward system, the air supplied being delivered to outlet registers near the ceiling or at considerable elevation above the floor, while all exhaust connections have intake registers at or near the floor line. All registers both for fresh air outlets and exhaust, are fitted with screens of narrow flat wire of 1¼-in. mesh which are mounted on wall frames of the reverse bevel pattern, and all fresh air outlets have in addition diffusers attached which are adjustable and may be set to spread the air into any portion of the room desired. The amounts of air supply provided for each of the rooms served were designed with reference to the heat loss by both the exterior exposure and the change of air in ventilation, the amount of air required for ample ventilation being thereby secured. The duct lines are proportioned for comparatively low velocities, the average velocity of flow being but 500 ft. per minute in the duct lines and flue risers, which velocities are further reduced in the outlet register connections.

Provisions for exhaust registers have also been made in all of the rooms fitted for indirect heating in order that free circulation of air in these rooms may be secured for ventilation purposes. Systems of masonry flues are incorporated in the building construction in arrangement similar to that of the fresh air supply risers which have register openings into the rooms served at their bases and rise to hooded outlets above the roof. The flues have galvanized iron sweep sheets at their bases, similar to the fresh air supply risers, and the register openings are similar in construction and size to those for fresh air supply to the various rooms. No dampers are provided in these flue connections, closure, in case the ventilating systems are shut down, being effected by the usual register dampers. The exhaust flues, connections and registers are similar in size to those of the fresh air supply system, for capacity of exhaust equal to that of supply, but no mechanical exhaust equipment has been provided, these vent flues operating by natural draft. Exception to this occurs only in the toilet-room vents, in which rooms positive changes of air were desired regardless of the operation of the fresh air supply system. For this purpose aspirating coils or stacks were installed in the flue from each of the large toilet-rooms at either side of the central portion of the building, the coils each consisting of two 9 sq. ft. colonial sections of cast-iron radiation which are placed in the vent flues just above the inlet openings.

The power plant of the Home is located in the basement of a 36x60-ft. one-story extension at the rear of the south wing of the building, the first floor of which accommodates the kitchen and culinary department of the building. The basement space is divided into a 34-ft. section accommodating the boilers, pumps and auxiliary equipment and a 25-ft. section for the engine and electrical generating equipment. The floor is depressed about 9 ft. below grade, giving a clear head-room of 14 ft. in both rooms and ample daylight lighting is provided by side windows above the grade line. A stairway opening on the inner court side provides for access to the boiler-room from the outside for machinery parts, etc., and on the opposite side there is an underground storage bin, 15x34 ft. in plan, built of concrete retaining walls alongside of the boiler-room with floor on level with that of the latter room and covered over the top with a 7-in. reinforced concrete slab. This arrangement of bin greatly facilitates the storage of coal, coal being delivered to the same by driving coal wagons directly on to the roof of the bunker and discharging through coal holes. The bunker has a capacity of about 150 tons if filled to the roof and coal is handled to the boiler room by wheeling from a door at the forward end conveniently located opposite the firing floor in front of the boilers.



Ventilation of Chapel and Dormitories.

The equipment of the power plant consists of two 70 h.-p. return tubular boilers with space available for a third unit, which supply steam for the heating of the building and for the operation of a 25-kw. electrical generator unit in the adjoining room. The boilers are set in a substantial brick setting on the side of the room adjoining the coal bunker with a 10-ft. firing floor at the front and a 5-ft. space at the rear for blow-off and breeching connections, while a space of 16 ft. is left at the opposite side for a possible future unit and the auxiliary equipment of pumps, feed water heaters, etc. The boiler furnaces are fitted with shaking grates for hand firing which were designed for operation with bituminous coal. The products of combustion are removed to the stack by a 34x40-in. iron breeching, built of No. 8 sheet steel and heavily covered with asbestos blocks and fitted with a large swinging damper for regulation of the draft. The breeching is arranged over the boiler fronts to facilitate extension to a future third boiler unit if additional capacity should be needed.

The boilers are of the fire tube type with 60-in. shells, 14 ft. in length, and each contain fifty-four 3½-in. tubes. They were built by the Gem City Boiler Works, and designed for operation with a working pressure of 125 lb. per square inch. They are without domes, but are fitted with 7-in. perforated dry pipes, 7 ft. in length, through which steam is delivered to the nozzles. Each boiler has three nozzles, one 2 in. in size for connection to an auxiliary steam line in the boiler-room, a 6-in. nozzle at the middle for the main steam header connection and a 4-in. nozzle at the rear for the safety valve. The outlet from the latter is piped to deliver into the stack through a 5-in. vapor line. The boilers are fed through 2-in. branches from a 2½-in. feed line carried over the boiler fronts and each has a 2-in. blow-off connection from the rear end of the shell connecting to a 2½-in. line which delivers into a blow-off tank in the rear portion of the boiler-room. The blow-off tank is a circular cast-iron receptacle 36 in. in diameter by 36 in. deep with a 3-in. vent pipe carried up through the roof and it has a 4-in. overflow connection to the sewer in the adjoining street with check valve and an auxiliary connection to a catch basin in the boiler-room floor which may be used in case of water backing up in the sewer; this catch basin is drained by a 2-in. ejector which is installed to raise any water from this source or from boiler-room drainage into the sewer.

The boiler-room auxiliaries consist of two pumps and a feed water heater, one of the pumps a plain boiler feed pump and the other a receiver pump for the return of condensation from the heating system. The pumps are both brass-fitted duplex pumps with 6x4x6-in. cylinders and the condensation receiver is of the usual type fitted with float valve for the automatic control of the pump, the suction connection to the receiver pump being tapped for a cold water chilling or condensing connection to condense vapor and chill the returns if coming from the heating system too hot. This boiler feeding equipment is supplemented by an injector of 150 h.-p. capacity which has connections to the cold water supply and delivers to the main boiler feed header. The feed water is heated in a closed tube heater which is designed to heat 3,000 lb. of water per hour from 40 deg. F. to 200 deg. with exhaust steam at ½ lb. pressure; it contains 40 sq. ft. of heating surface, made up of 1½-in. brass tubes No. 13 gauge, and is so connected that the water heated by it may be delivered either to the boilers or to the hot water service of the plumbing system. Steam is supplied to the pumps and injector by a 2-in. auxiliary boiler-room main which connects with the 2-in. nozzles on the boilers, connections also being made from this line to the domestic water heater for use with high pressure steam to the exclusion of exhaust if desired.

The water supply from the boilers is derived principally from the condensation returns from the heating system, with make-up from the city water system.

The electrical generating equipment consists of a 50 h.-p. simple horizontal engine, direct connected to a 25-kw. direct current multipolar generator which is operated at 220 volts for lighting and power service in the building. The engine is a simple automatic engine of the heavy duty self-oiling type, built by the Atlas Engine Co., and is designed to deliver full capacity with an initial steam pressure of from 60 to 90 lb., and a back pressure operating non-condensing of 5 lb. per square inch, when operating at 300 r. p. m. It is supplied with steam by a 4-in. branch from the 7-in. boiler-room high-pressure header and exhausts through a 5-in. connection with oil separator into the 6-in. basement exhaust and heating main. The engine is fitted for close regulation and is capable of withstanding an overload of 25 per cent for an extended period. The generator is a 220-volt direct current multipolar machine, supplied by the Fort Wayne Electric Co., which similarly has an overload capacity of 25 per cent., for an extended period without overheating. The electrical system in the building to be operated comprises 850 16-candle power lamps, distribution to which is made on a wiring system having 87 circuits and 359 outlets in the various parts of the building.

The building was designed and the power plant and heating and ventilating equipment laid out by Stratton & Baldwin, architects, Detroit, Mich. Mr. F. F. Van Tuyl was consulting engineer for the power and heating and ventilating equipments.

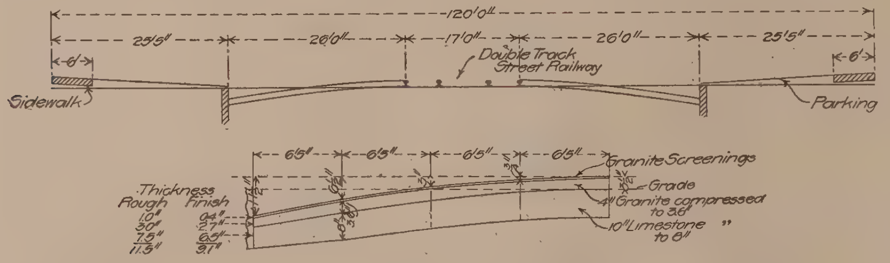
Fly-Wheel Insurance Rates have been decreased 20 per cent. by one of the casualty companies in case the power plants are equipped with an approved engine stop and speed limit system. The company has found that such apparatus affords such a degree of protection from accidents that its use in any plant should be recognized by the reduced rate mentioned.

Granite-Top Macadam Pavement in St. Paul, Minn.

University Ave., in St. Paul, Minn., was paved with granite-top limestone macadam for a length of three miles last year, and the same pavement is now being laid on the portion of the street extending from the end of this work to a point near the city limits. This street is the main thoroughfare between St. Paul and Minneapolis, a large volume of all kinds of traffic being tributary to it. It has a clear width of 120 ft. from lot line to lot line, and is paved to a width of 69 ft. A double-track street railway is placed in a 17-ft. strip at the center, thus leaving a 26-ft. roadway on each side.

The cross-section of the street and a detailed cross-section of one of the 26-ft. roadways are shown in an accompanying illustration. The 6-ft. walk on each side of the street abuts against the lot lines, providing a parking, 19.5 ft. wide between it and the curb. The curb is of Kettle River sandstone, 5 in. thick at the top, when dressed, and is set on a sand foundation. The macadam has a total thickness of 12 in. at crown, and at the quarter points of the distance between curbs, and of 9 in. at the gutter. The soil on which the macadam is laid directly, after the grading has been done, is quite sandy and of considerable carrying capacity.

The macadam is laid in three courses, a footing course of crushed limestone, a wearing course of crushed granite and a finishing coat of limestone screenings. During the laying of each of the three courses of stone a quantity of Westrumite, a proprietory liquid preparation, is applied, the intention being to apply 1 gal. of the preparation to each square yard of pavement. This preparation is a liquid compound which makes an emulsion in water and has peculiar qualities for laying dust.



Cross-Section of Macadam Pavement on University Avenue, St. Paul.

The limestone in the footing course of the macadam is required to consist of pieces which will pass a 2½-in. ring in their greatest dimensions and none of which shall be less than 1 in. in the smallest dimensions. This stone is placed to a depth of about 9½ in. at the crown and quarter points of the street and 7½ in. at the gutter. On it is spread a sufficient amount of limestone screenings to fill the voids. The stone is then sprinkled with water and rolled with a 10-ton roller until an even surface is produced. A ½-in. layer of limstone screenings saturated with a 50 per cent. solution of the Westrumite is then applied, after which the course is rolled until it is thoroughly compacted, sprinkling being done during the rolling with a 10 per cent. solution of Westrumite. The footing course finished in this manner is intended to have a full depth of 8 in. at the crown and quarter points and of 6 in. at the curb.

The wearing course consists of New Ulm, Minn., granite, crushed so all pieces will pass a 1½-in. ring, but none of them less than ½ in. in their smallest dimensions. This crushed granite is placed to a depth of 4 in. at the crown and quarter points of the street, and 3 in. at the gutter before rolling. Prior to and during the rolling the stones of the course are thoroughly sprinkled with a 10 per cent solution of the Westrumite.

Limestone screenings, saturated with a 50 per cent. solution of the Westrumite are then spread over the course to a depth of 1 in., or so as to fill all interstices, and are then rolled thoroughly. During this rolling the screenings are sprinkled with a 50 per cent. solution of the liquid compound, at least 2 quarts of the latter being used to the square yard of surface. The granite and the layer of screenings are intended to have a depth of fully 3.6 in. at the crown and quarter points of the street, and of 2.7 in. at the gutter, when finished. After the roadway is finished to the required thickness, it is sprinkled four times with a 15 per cent. solution of Westrumite. These sprinklings necessitate the use of about 1 quart of the liquid per square yard of surface; sufficient intervals are allowed between the sprinklings to permit the previous application to become thoroughly dry.

The space between the car tracks is paved by the street railway company according to plans approved by the city. In this work, however, no Westrumite was used, except in applying the top layer of crushed granite, and the limestone screenings.

During the year it has been in service, the pavement built by the city has been very satisfactory under the heavy traffic which it carries. The surface has been sprinkled about once in 10 days during the summer, and is as free from dust as is a street regularly sprinkled with water several times a day. At the same time, this portion of the street is so far from the center of the city that it is impracticable to sweep it regularly.

The macadam was built at a cost of $1.40 a square yard, including the cost of the proprietary compound, but exclusive of grading, curbs, and so forth.

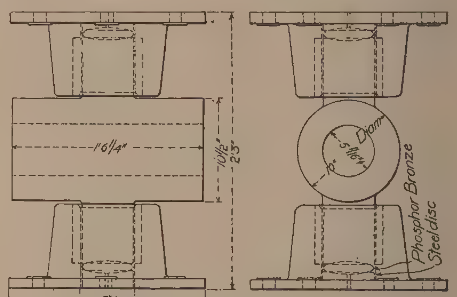
The plans for this pavement were prepared and carried out under the general supervision of Mr. L. W. Rundlett, commissioner of public works of St. Paul. Mr. A. B. Starkey, assistant commissioner of public works, who personally directed the execution of the work, supplied the data from which these notes have been prepared.

An Engineering College for Chinese Students is to be opened at Tongshan, China, by the Imperial Railway management in conjunction with the Chinese Engineering & Mining Co. Accommodations will be provided for about 140 students.

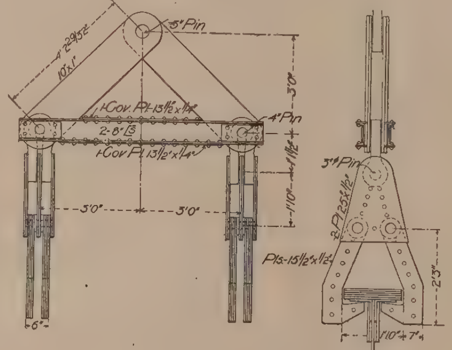
Erecting Six-Track Plate Girder Bridges With a Derrick Car.

Improvements now being made on the Harlem Branch of the New York, New Haven & Hartford R. R. include the abolition of grade-crossings at many points by the elevation of the two existing tracks, the addition of two new tracks and the building of sub-structures for these four tracks and to provide for two more tracks of the New York connecting railway which will hereafter be installed. In some cases the crossings are made with single spans and in more cases with a long center span over the street and two short approach spans over the sidewalks. The maximum widths of crossings are 100 ft., and the maximum length and weight of girders are 80 ft., and 60 tons respectively.

The concrete piers and abutments are built in two successive sections approximately symmetrical about their center lines. The first section includes about one-half of the substructure adjacent to the present low level double track and as close to it as will allow clearance for trains. These portions are made to accommodate three tracks and after their completion two tracks will be installed on them, traffic transferred to them from the low level tracks and the latter abandoned. The present low level tracks will then be removed and the remainder of the substructure completed on the side previously occupied by them. Finally, the super-structure for the third and fourth and for the fifth and sixth tracks will be erected on the completed substructure. The bridges are made with double track units, each of them consisting of three girders. Most of the girders have through floors and are 14 ft. 4½ in. apart on centers.



Connection at Top of Mast.

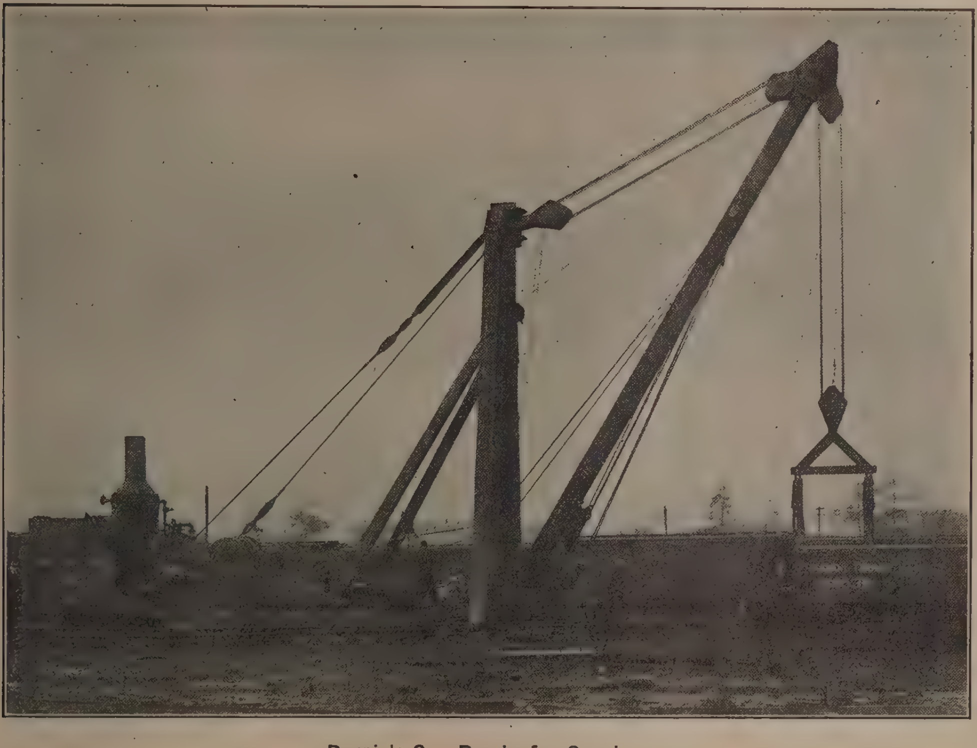


Lifting Device for Derrick Car.

A contract for the fabrication of structural steel has been awarded to the Pennsylvania Steel Co. Another contract for the erection of 18 spans has been awarded to the Lucius Co., which has designed and constructed a special derrick car intended to erect the girders with the maximum safety, rapidity and economy and to be suitable for erecting miscellaneous railroad girders after the completion of this contract. The car and its equipment weighs about 80 tons and has a boom 52 ft. long which can swing through a horizontal arc of 180 deg., with a capacity of 45 tons at a radius of 36 ft. 6 in., and of 60 tons at a radius of 23 ft. 6 in. In service it requires a vertical and horizontal clearance of 40 and 20 ft. respectively and when dismantled for transportation has a height of 12 ft. and a width of 9½ ft.

The car body is 9½ ft. wide by 55 ft. long and is of massive construction with six full-length longitudinal plate girders. A riveted pedestal about 7½ ft. long, 9½ ft. wide and 3 ft. high is seated on the forward truck to receive the mast and boom. It is of very strong cellular construction made with longitudinal and transverse web plates ½ and ¾ in. thick, reinforced by very heavy flange and web-stiffening angles. In the rear it has two horizontal pins 4 in. in diameter serving as pivots for the feet of two inclined posts 32 ft. ft. long on centers which are pin-connected at the top to form the triangular A-frame or mast.

The boilers, water tank and coal bunkers are installed over the rear truck and the hoisting engine is located between the trucks. The inclined posts of the A-frame are made with pairs of 18-in. built channels latticed, and are rigidly connected by a transverse horizontal strut at the bottom and by a riveted box at the top which receives the steel casting for the hoisting and topping lift tackles. The A-frame is maintained in vertical position by a pair of inclined struts and by a pair of 1¾-in. wire cable back stays with turn buckle adjustments, pin-connected to forged links engaging the top of the mast and the body of the car and the outside girders in the car body near the rear truck. The inclined struts are a pair of 12 x 12-in. timbers 25 ft. long with pivoted connections to the car body and to the mast about 12 ft. below its upper end.



Derrick Car Ready for Service.

The 24 x 24-in. boom has a rectangular cross section made with two built channels having their flanges turned inward and latticed. It is field spliced in the middle with web and flange cover plates bolted on. Near the middle of the outer section it is provided with pin connections for transverse swinging tackles. The rectangular water tank has a narrow coal bunker on each side which partly enclose the boiler and carry about 2 tons of coal. The tank has a capacity of 500 gallons which with the coal is equivalent to about a 4-days' supply for the derrick engine thus making it independent of a tender car.

The cast steel foot block for the boom is made to offset it 26 in. on centers, from the mast, thus allowing it to revolve through a complete horizontal semi-circle. It consists, as shown in the detail, of three parts, the jaws, the pivots, and the bearings. The jaws have a 5-in. horizontal boom pin offset 13 in. from the center of the vertical pivot about 8 in. in diameter. The upper end of the pivot is secured by a horizontal plate in the pedestal and the lower end has a concave bearing on a double convex phosphor bronze disc seated on a hardened steel disc. The casting is secured to the riveted pedestal by twelve 29/32-in. turnbolts.

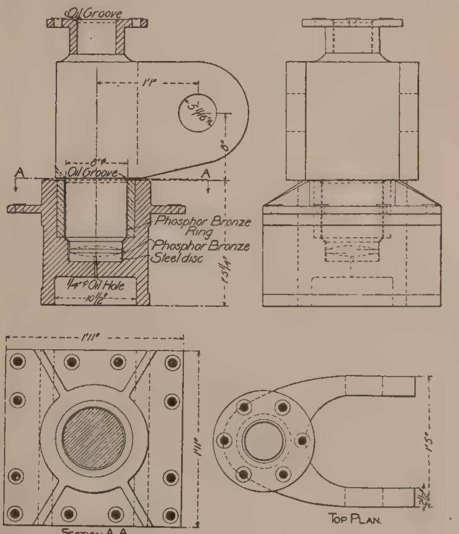
At the top of the mast two flanged vertical cast steel cylinders are bolted to the riveted box and receive the trunnions of a horizontal cylindrical casting 10 in. in diameter and 18 in. long which is bored through its axis for a 5-in. pin engaging a pair of short links which connect to it the large special steel blocks containing the sheaves for the hoisting and topping lift tackles.

Special lifting devices are provided for handling the 60-ton girders; each of them consists of two pairs of riveted hooks suspended from the extremities of a horizontal beam 6 ft. long. Each hook is made with four thicknesses of 15½ x ½-in. sheared plates riveted together. The lower ends are slightly bevelled so as to take bearing at their extremities only where they engage the under sides of the top flanges of the girders between rivet heads which prevent them from slipping longitudinally. The upper ends are bored for 3-in. pins engaging three vertical connection plates, each of them made with two 25 x ½-in. sheared plates riveted together. The upper ends of the plates are pin-connected to a shackle made with a 3 x 3-in. steel bar, the loop of which engages a 4-in. pin through the end of the transverse beam. The beam, 7¼ ft. long over all, has a closed rectangular cross section made with two 8-in. channels and two 13 x ¼-in. flange cover plates and is suspended from the tackle by two links about 4¼ ft. long on centers which are made with pairs of 10 x 1-in. sheared plates engaging a single 3-in. pin which connects them to the tackle. This device weighs about 3,000 lb., is very easily and quickly adjustable and is considered to be very safe.

The hoisting and topping lift tackles respectively have ¾-in. and ⅞-in. steel ropes rove over six 24-in. sheaves in special steel blocks with self-oiling bronze bushing and ⅜-in. separating plates which were built by W. W. Paterson & Co., Pittsburg. The tackles are operated by a special 75 h.-p., 12 x 16-in. engine, designed by the Lucius Co., and built by the National Hoisting Engine Co. It is able to hoist a 24,000-ib. load on a single line at a speed of 100 ft. per minute and all of its operating levers are concentrated on a single quadrant rack so that they can be handled by one man.

When in service the derrick car is located on the end of the high level track near the top of one of the abutments of the span to be erected. The rear trucks are anchored to the track by ordinary hook clamps operated by adjustment screws. The front truck is blocked up and if necessary the rear end of the car floor is clamped to the forward end of a loaded flat car, thus increasing the stability. The girders are successively brought alongside, on the flat cars in which they have been shipped from the bridge shop, and are lifted clear by the derrick which swings them off from the car and lowers them to the ground in front of the abutment transverse to the railroad track. Afterwards the derrick car in the same position lifts the girders successively to the top of the abutment, revolves them 90 degrees and lowers them to their final position on the bridge seat. Ordinarily, one double track span is erected complete in about 1½ days with a total force of 8 men. The through spans have trough floors shipped in 5-ton sections field riveted at splices by Boyer pneumatic hammers using air from a Franklin compressor of 300 cu. ft. per minute capacity in an attendant box car.

It takes about half a day to dismantle the car for transportation, which is done by revolving the mast backward into an inclined position with the rear ends supported on blocking over the engine. The struts and back stays are disconnected and transverse braces are disconnected from the mast and are loaded on the derrick car. The boom is lowered to a horizontal position on a flat car in front of the derrick car and is disconnected from the mast and the middle splice unbolted if necessary. After transportation the car can be put in service in about half a day.



Boom Pivot.

The Inclined Railway at Lyon-Croix-Rousse, France, has recently been equipped with an electrical operating system to displace the original steam plant with which the cars were formerly operated. The incline is 1,500 ft. long, with a grade of slightly more than 17 per cent., and the cars are operated by a pair of 18-ft. drums, each working a single cable, which are now connected through a single-gear reduction drive to a 250-h.-p. direct-current motor supplied with current at 600 volts. The cable is operated at a speed of about 15 ft. per second and the train, consisting of a baggage and a passenger car, weighing about 20 tons net or 34 tons fully loaded, requires about 340 h.-p. to accelerate. An economic feature is the use of a storage battery of 275 ampere-hours capacity for emergencies and to assist in starting, and into this battery current is returned from the motor as the train is running down the incline, by connecting the motor as a dynamo and charging through a booster set.

The Rehabilitation of the Tracks of the Chicago Street Railway.

An ordinance passed by the city council of Chicago early in this year requires the interests controlling the street railways of that city to rehabilitate practically their entire systems within three years from the time this ordinance became effective. This immediate rehabilitation includes the complete reconstruction of the tracks of a large percentage of the total mileage in the city, the provision of an adequate number of modern cars to properly handle traffic, and the installation of sufficient additional electrical-generating equipment so power to operate the various lines satisfactorily can be furnished. After the expiration of the first three years, the remaining lines are to be similarly rehabilitated until the street railways in the whole city have been placed in a satisfactory operating condition. The same ordinance also covers a number of features concerning the franchises under which the street railways are to be operated and other relations between the street railway interests and the city.

The ordinance has been accepted by the Chicago City Ry. Co., which owns and operates the lines on the south side of the city, and this company has already carried on a large amount of work according to requirements set forth. The Chicago Union Traction Co., which operates the systems on the north and west sides, will doubtless also accept the ordinance as soon as the interests controlling that company can adjust their finances satisfactorily.

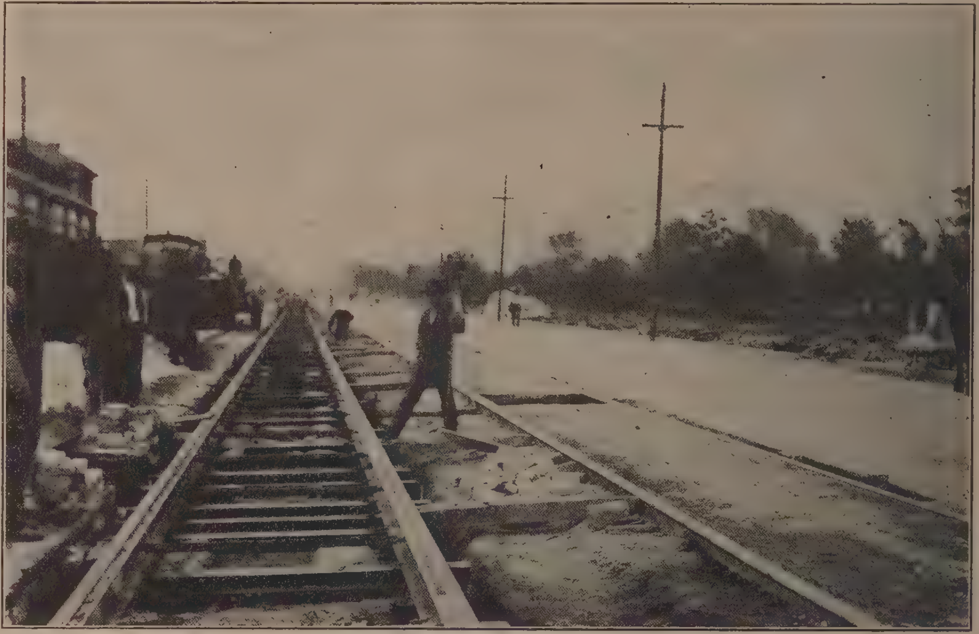
This rehabilitation of the three systems which embrace all the lines in the city is being done by, and at the expense of the street railway interests, under the direction of a board of supervising engineers consisting of Messrs. Bion J. Arnold, chairman, Charles V. Weston, representing the city, Harvey B. Fleming, representing the Chicago City Ry. Co., and John Z. Murphy, acting for the Chicago Union Traction Co. Mr. Arnold is chief engineer and Mr. George Weston is assistant chief engineer of this board.

The Chicago City Ry. Co. had rebuilt in the neighborhood of 6 miles of track on October 1, and had over 10 miles of track reconstruction under way at that time. An average of about one-third of a mile of single track is being laid each day by this company, and with favorable weather one-third of the total mileage to be reconstructed in the first three years will be finished in 1907, although the work was not started until late this season. The Chicago Union Traction Co. is also carrying on a large amount of track reconstruction according to the standards specified by the board of supervising engineers, in order that this work will be properly done in case the interests of this company are adjusted so the ordinances can be accepted by it, as will undoubtedly be done.

Three types of track construction have been adopted by the board of supervising engineers for use under different conditions. Although these three types have been practically standardized, a few minor changes are to be made in them, so the board has decided not to make public the details of the different types. At the same time, the general features of the latter have been supplied to this journal. A standard girder rail, the cross-section of which is shown in an accompanying illustration, is used in all three types. In one type the rails are laid on steel cross-ties, imbedded in concrete, and in the other two types on wooden cross-ties, also imbedded in concrete; the difference between the two types in which wooden cross-ties are used appears largely in the construction of the subbase on which the track is laid.

The steel ties are of the standard 4½-in. Carnegie girder section. They are placed on a heavy sub-base of concrete and are imbedded in a layer of concrete, which is continued 2½ in. above the base of the rails. In some of the work that has been done these ties were spaced 5 ft. apart on centers, but in most cases they are 4 ft. apart on centers, and it is probable that the shorter spacing will be adopted as the standard. Sawed wooden ties, 6 x 8 in. in cross section, and 7 or 8 ft. long, are used. They are also imbedded in a layer of concrete, which for one type of track is laid on a sub-base of crushed stone and for the other on a sub-base of concrete. These ties are spaced 4 ft. on centers.

The chief feature of all of the track construction is that the sub-structure is designed to be unusually permanent, and is built so the rails may be renewed with comparatively little difficulty and without disturbing the substructure. Tie plates are used on both the steel and the wooden cross-ties. The rails are attached to the steel ties by a special clip, which can be removed and replaced readily, and which was designed for use in connection with this work. Screw spikes are used to attach the rails to the wooden ties, with the belief that the life of the latter will thus be considerably prolonged.



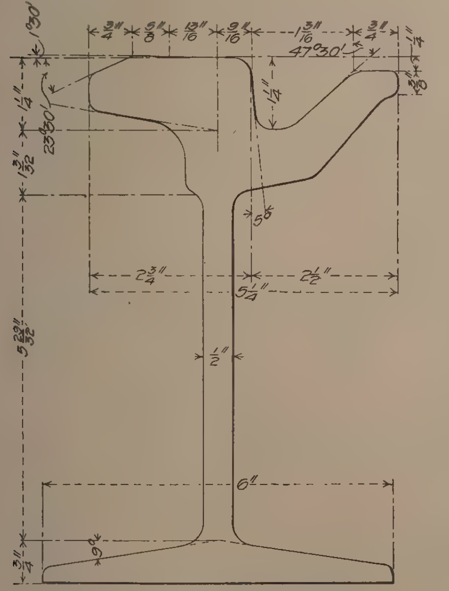
A Stretch of Track with Steel Ties Ready for Substructure.

The standard grooved rail used in all of the track reconstruction was designed specially for the conditions existing in Chicago. This rail weighs 129 lb. per yard, and is rolled by the Lorain Steel Co. Although the section of the rail is generally the same as that of several grooved girder rails which have been used in various cities in this country, it differs essentially in several important features. After making a long series of studies of the effect of wear on previous rails of this type, considerable metal was added to the outside of the head just above the top of the web, as these studies indicated that an increase in section at that point would add materially to the serviceable life of the rail. The thickness of the metal directly under the groove has also been increased for the same reason. The outer edge of the rail is beveled, and the pavement is finished ¼ in. below the top of the rail on that side. The head of the rail can thus be worn down until the flange of the car wheels ride on the groove before the treads of the car wheels reach the pavement. The slope on the outside edge of the head of the rail thus increases the permissible wear to a maximum, with a wheel tread not exceeding 2⅞ in. The groove has been designed for cars with wheels having ⅝-in. flanges, with a possibility of an increase to ¾ in. While flanges of this width are scarcely suited for high-speed interurban cars, and some criticism has been offered against the adopted type of groove, the latter was designed strictly for traffic conditions in Chicago, where few, if any, high-speed interurban cars enter the city.

Two other conditions also had to be met in designing the grooved portion of the head of the rail, first, a groove which would prevent the wheels of vehicles entering it, and second, a groove which would be self-cleaning, was desired. As both of these conditions cannot be perfectly fulfilled by the same groove, a compromise has been made between them in this case. The rail is rolled so the extreme outer lip of the groove is ¼ in. below the top of the head of rail. The granite paving blocks used between the rails are laid so their tops are ⅛ in. higher than the outer lip of the groove, with the result that the paving will hardly wear below this lip. The wheels of behicles can therefore readily enter and leave the tracks, while the shape of the groove is such that it will be nearly free from dirt.

Track Construction Methods.—The methods followed in the reconstruction of the two tracks of the line on Cottage Grove Ave. are more or less typical of the manner in which work has to be handled on the heavy traffic lines. This line is one of the most important in the system of the Chicago City Ry. Co., extending southeast from the downtown business district for about nine miles to a connection with a line leading to South Chicago. Throughout practically its entire length it passes through a densely built-up residence district and connects with numerous important cross-town lines. It was completed prior to 1890 and was operated as a cable road until last year, when an overhead trolley was installed. As is common with a very large percentage of the total mileage in the city, the old rails on this line had not been renewed for years and scarcely any repairs, other than those which were absolutely essential, had been made during the long period that the city held the settlement of the various street railway franchises in abeyance. These conditions, combined with the use of the long, heavy cars which were installed last year after the line was electrified, had put the tracks in very bad shape, so the track and the upper part of the sub-structure are being removed and replaced by the type of track having steel cross-ties that has been recommended by the board of supervising engineers.

The reconstruction work is handled in sections, a single track of each section being rebuilt at a time. On this particular line the traffic is so heavy that it is impracticable to divert it all over one track, even for short distances, so a third temporary track, laid on the pavement at one side, is used to carry the cars of the regular track that is out of service. On some other lines traffic from one track has been diverted over a parallel line, but on Cottage Grove Ave. several conditions combine to make that arrangement also impracticable, so the temporary third track is essentially necessary.



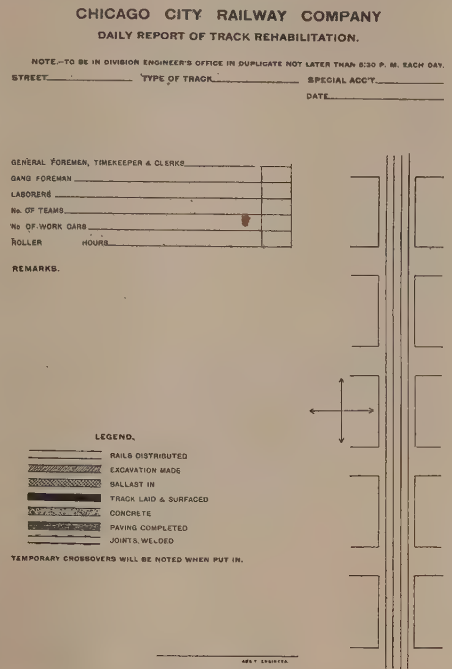
Standard Grooved Rail Section.

The cable formerly used to haul the cars over this line operated in a concrete conduit under the center line of each track. The rails were carried by chairs on iron brackets, or yokes, cantilevered out on each side of the heavy concrete conduit. The rails, chairs and part of the yokes have to be removed and a considerable part of the conduit has to be cut away before the new track can be built. This preliminary work is handled with considerable difficulty, particularly the cutting out of the concrete, which has been done thus far by hand with cold chisels, picks and so forth. Arrangements have been made, however, to install a number of Little Jap pneumatic hammers for use in cutting the concrete, the power for these hammers to be supplied by portable compressor outfits.

The excavation for a track is made and the sub-grade is prepared for considerable distances, depending in length on local conditions, before any concrete work is done. The ties are then laid in the excavation and are blocked up to their regular positions, after which the rails are attached to them. The layer of concrete on which the ties rest and in which they are imbedded is then laid up to 2½ in. above the top of the ties, except at the joints, where it is stopped level with the top of the ties in order to permit the rails to be welded later without disturbing the concrete.

The concrete is produced by a mixer outfit mounted on a frame carried by two four-wheel car trucks. This outfit was built specially for use in this work by the Drake Standard Machine Works, of Chicago, and is operated over the rails as they are blocked up in place before the concrete is laid. The frame of the outfit is 48 ft. long and is built of structural steel. A standard Drake concrete mixer is mounted under one end of the frame where it can discharge the concrete directly into place under and around the ties and rails. Concrete materials are supplied to the mixer by a flight chain conveyor which runs the full length of the frame, the materials being shoveled into the conveyor from storage piles on the pavement on the roadway side of the track.

The concrete is made in the proportions of 1 part cement, 3 parts sand and 6 parts broken stone. These materials are piled along the track in such manner that as they are shoveled into the conveyor they are in the proper proportions for the concrete. This is accomplished by first placing a layer of sand of a predetermined depth and width on the pavement, and over that a layer of broken stone and then a layer of cement. The sand and stone are delivered in wagons, from which they are dumped directly in place on the pavement, the layer of sand being kept considerably in advance of the stone. The required width and depth of the sand and stone is measured by templates, while the number of bags of cement to be used is determined by computation. By following this method the materials are readily placed in the piles in the proper proportions, with a minimum amount of rehandling after they have been delivered.



CHICAGO CITY RAILWAY COMPANY

DAILY REPORT OF TRACK REHABILITATION.

NOTE.—TO BE IN DIVISION ENGINEER'S OFFICE IN DUPLICATE NOT LATER THAN 5:30 P. M. EACH DAY.

STREET______ TYPE OF TRACK______ SPECIAL ACC'T.______

DATE______

GENERAL FOREMEN, TIMEKEEPER & CLERKS______
GANG FOREMAN______
LABORERS______
No. OF TEAMS______
No OF WORK CARS______
ROLLER HOURS______

REMARKS.

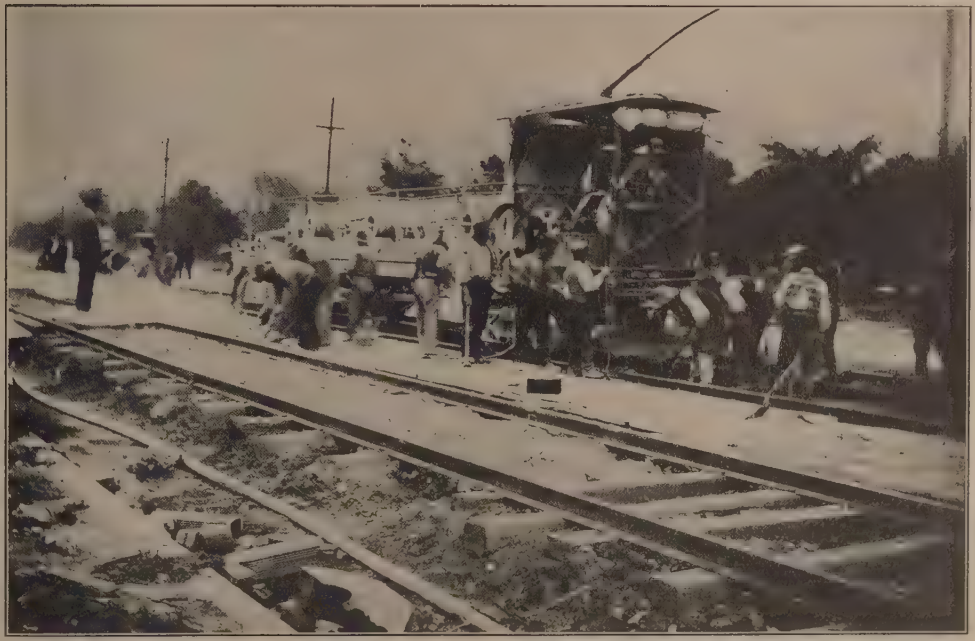
LEGEND.

═ RAILS DISTRIBUTED
▨ EXCAVATION MADE
▩ BALLAST IN
■ TRACK LAID & SURFACED
▒ CONCRETE
▓ PAVING COMPLETED
═ JOINTS WELDED

TEMPORARY CROSSOVERS WILL BE NOTED WHEN PUT IN.

______
ASS'T ENGINEER.

Daily Report Blank.



Concrete Mixing Outfit Used in Placing Track Substructure.

The materials are shoveled from the measured piles into the conveyor by from 10 to 15 men, depending on conditions. The frame of the mixing outfit was placed 51 in. above the top of the rail, in order to permit the men shoveling materials into the conveyor to straighten up each time they lift a shovelful, with the result that they can work at a higher rate of speed with less fatigue than though the frame was lower so they could not stand straight each time. A row of sheet metal deflectors, placed along the opposite side of the conveyor from the shovelers directs the materials into a trough in which the chain travels. These deflectors are arranged so they may be placed on either side of the conveyor, depending on the position of the shovelers.

The conveyor is a wide-link chain, which on its lower run travels in a cast-iron trough, carried by two Z-bars, attached to the main frame, and on the return run is carried above this trough on three loose spools. The conveyor delivers the materials directly into the hopper of the mixer and has operated with excellent results.

The mixer, which is of the pug-mill, continuous-feed type, is placed on the longitudinal center line of the frame. The concrete is discharged from it on an apron, which extends the width of the track just above the rails. It is distributed and tamped in place by six to eight men, who are required to work very rapidly to keep pace with the machine. The blocks on which the ties and rails are held up in position until the concrete is placed are removed under the alternate ties just before the concrete reaches them; the dead load of the track being carried by the remaining blocks gives the concrete an opportunity to set, as cars are not turned over the track for several days after the concrete has been laid.

The mixer is gear-driven by a 30-h. p. motor, which also drives the conveyor. While running 8 to 10 h. p. is fully sufficient for these purposes, but on starting considerably more power is required for a short period. The car is propelled by two 75-h. p. street railway motors, placed on the rear truck, as a low-front truck, taken from an old trailer car had to be used under the front end, in order to provide room between the axle of the truck and the frame of the car for the mixer. Power for all three motors is obtained from the trolley.

The amount of concrete track substructure laid in a day by the machine depends largely on the rapidity with which the excavation and the sub-grade can be prepared. Under average conditions, however, 750 ft. of substructure will be finished in a 10-hr. day, requiring about 250 cu. yd. of concrete. When the machine is delivering that amount of concrete 10 shovelers can supply it with materials. The machine has been in almost continuous service since the latter part of August and has produced such good results that the Chicago City Ry. Co. has purchased three more of the machines for work of the same kind.

The work that has been done on the other lines of this company is all handled in a manner similar to the methods which have been described, although on most lines traffic is diverted from the track under reconstruction to another street, or on lines with light travel the traffic is all turned over one track for short distances. The track reconstruction is carried on by separate gangs of men, about 2,500 men being employed in this work by the company. Each gang is under the immediate direction of a general foreman, thoroughly experienced in street railway track construction, and an assistant engineer has general supervision of the gang. These assistant engineers are all under Mr. W. F. Graves, who is division engineer in charge of track reconstruction for the Chicago City Ry. Co.

Each assistant engineer reports daily to the division engineer the general features of his work. One of the blanks used for these reports is shown in accompanying illustration, from which the method of recording the location of the construction gang on any street for any day and of indicating the amount and kind of work done each day is evident.

The organization of the board of supervising engineers is separated into several divisions, Mr. R. F. Kelker, Jr., being division engineer, and Mr. C. E. Thomas assistant division engineer of track and roadway. Under this division is a corps of engineer inspectors, who follow closely the construction and report daily to the division engineer the progress and other features of the work.

Although the track reconstruction, as well as all the other rehabilitation work, is carried on at the expense of the street railway company, the cost of this work is to be added to a previously agreed valuation of the whole street railway system, and the city will have to pay this total value if it eventually acquires the systems, as maintenance, depreciation, repairs and renewals are provided for in the meantime by special funds supplied from the gross earnings. The detailed cost of the reconstruction is therefore very carefully kept independently by the company and by the board of supervising engineers. A large amount of cost data is thus obtained, which, aside from its value as a means of arriving at the total outlay, furnishes an excellent basis for estimating the expense of future work and for checking operations from day to day.

An Unusual Pipe Contract is now being finished for the Texas Co., of Beaumont, by the Youngstown Sheet & Tube Co. This contract calls for nearly 600 miles of 8-in. full-weight iron pipe, requiring over 50,000 tons of puddled iron plate. The line will cross a long stretch of alkali territory and accordingly every pipe has been heated to 350°, dipped in a bath of asphalt and then placed in a drying oven. The pipe will be used in carrying oil from Indian Territory to a Gulf refinery. The contract is interesting, not only on account of its size, but also because it has been filled with iron rather than steel pipe.

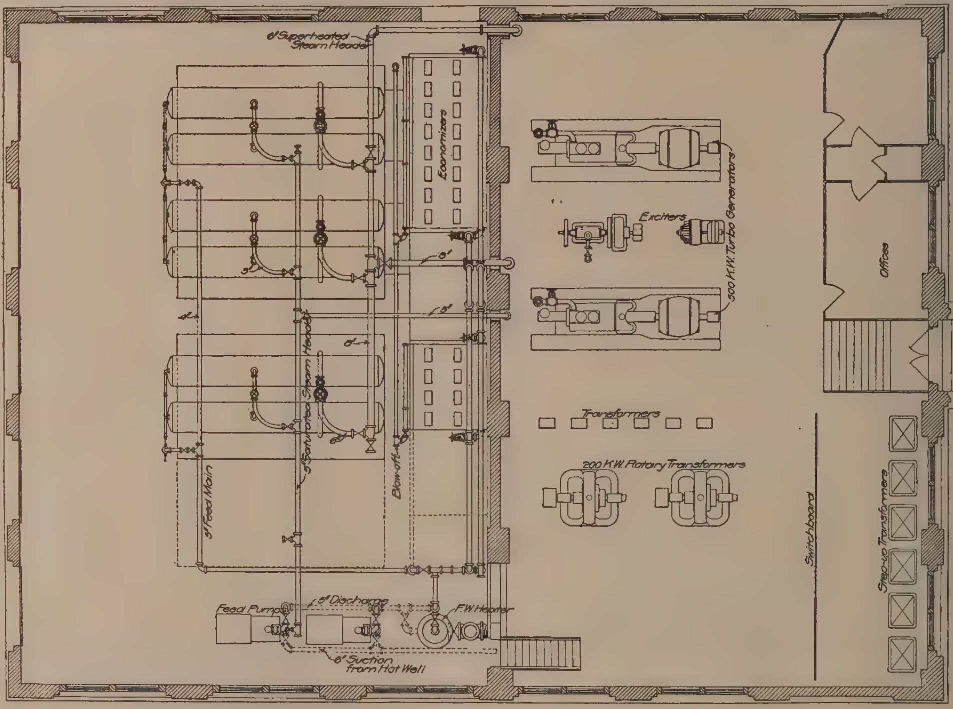
A Year's Experience with Gas Engines.

A paper presented to the American Street & Interurban Railway Engineering Association by Paul Winsor, Chief Engineer Motive Power and Rolling Stock, Boston Elevated Railway Co.

We have now been operating our gas-engine plants over a year. We have two of these plants, both of them generating direct current and feeding into our overhead system in multiple with our steam-driven power at stations. They have been operated most of the time by two 8-hr. watches from 7 a. m. to 11 p. m. and shut down from 11 p. m. to 7 a. m. The following figures and statements apply to our Somerville power station. I give no figures for our other plant as it has not yet been accepted. The Somerville power station has the following equipment: one pair of Loomis-Pettibone gas producers, with the usual auxiliaries; two 600-b.h.p. Crossley gas engines, each two cylinder, four cycle; two 350-kw. Crocker-Wheeler generators. This plant was started in May, 1906, and since then has given continuous, reliable and satisfactory service. There have been no shutdowns, no accidents, and no failures.

Gas Engine Operating Conditions at Somerville Station in 1907.

	Jan.	Feb.	March.	April.	May.	June.	July.	Total.	Average.
Kw.-hr. generated	204,080	175,200	192,250	202,870	118,640	35,770	60,170	988,980	....
Total lb. coal, including coke	391,223	364,817	405,050	401,150	234,705	90,991	124,452	2,012,388	....
Lb. coal per kw.-hr	1.917	2.081	2.120	1.975	1.979	2.542	2.065	....	2.034
Lb. coal per b. h. p. hour	1.322	1.436	1.426	1.363	1.365	1.755	1.425	....	1.404
Sta. load factor based on 16 hrs. per day and 7 days per week	58.8%	55.9%	55.3%	60.4%	34.2%	10.6%	17.3%	....	41.6%
Eng. load factor	84.2%	86.0%	87.4%	82.3%	78.3%	73.3%	82.8%	....	83.3%
Gen. load factor	99.3%	101.3%	103.0%	97.1%	92.4%	86.5%	97.7%	....	98.35%



Plan of Power Plant of the Gulfport and Mississippi Coast Traction Co.

The fuel has been soft coal, the same as used in our steam stations, mostly run-of-mine Pocahontas. The economic results are shown in the accompanying table.

These are the results from actual service and include all the fuel used for power, heating, etc., and the auditor's usual 1 per cent. to make his books balance.

We have used a great deal of water for scrubbing the gas and for cooling purposes. The average amount has been 281 lb. per kilowatt-hour. When we bought this water, as we did for a few months, our water cost about twice as much as our coal. We have been, since Nov. 21, 1906, pumping this from a very dirty brook by means of two-stage centrifugal pumps, electric driven, and filtering it through a pressure sand filter. This outfit has been entirely satisfactory and has given us no trouble. The suction lift is 12 ft. and the pressure at the pumps, 30 lb.

The discharge of water from the gas scrubbers is very dirty, being full of floating lampblack, and is altogether too black to put back into our dirty brook. A sand filter basin 246⅔ sq. ft. in area and tile under-drained, removes all the lampblack, so that we are turning back into the brook cleaner water than we take out.

Our ignition current is from 14-volt motor generators and a floating storage battery and we have no trouble with the outfit. The igniters are make-and-break, two to each cylinder. These igniters had originally platinum tips, which cost a great deal and gave considerable trouble. We have been running now four months without any platinum and with less trouble.

During the first months, back fires and preignitions were much too frequent. occurring almost every day. Lowering the compression on one of the cylinders, changes in the igniters, and experience have reduced these troubles, so that we now go two or three weeks without a single one.

This plant has proved absolutely reliable. It can be put into service any time in less than five minutes, much quicker than can our steam plants. It can carry good loads and do it continuously. Each unit has carried 450 kw. (652 b.h.p.) for an hour, with swings to 495 kw (717 b.h.p.).

For the first seven months of this year this plant used 2.034 lb. coal per kw.-hour, while our steam plants averaged 3.477 lb. per kw-hour, a saving of 41.5 per cent. One of our smaller steam plants, containing three 200-kw. compound condensing engines, used 4.414 lb. per kw.-hour; this gas station used only 46.1 per cent. as much.

Personally, I believe that a gas-engine plant, making its own producer gas, will operate at least as reliably as a steam plant and will use from 30 to 60 per cent. less fuel, depending somewhat on the size of the gas plant, but principally on the size of the steam plant.

The drawbacks to the gas plant are, in my mind: First, cost, approximating $200 per kw. when rated so as to have a 33⅓ per cent. overload capacity; second, small size of units, the largest gas engine now built being only of about 3,000-kw. capacity.

Power Plant of the Gulfport and Mississippi Coast Traction Co.

By Earl F. Scott, M. Am. Soc. M. E.

The power plant of the Gulfport & Mississippi Coast Traction Co. is located at Gulfport Miss., for the purpose of furnishing power for the interurban electric road connecting the towns along the Mississippi Coast, and furnishing light and power for the towns of Gulfport, Biloxi and Pass Christian.

The building is of fireproof construction throughout and designed to be pleasing to the eye. The exterior is stucco finish. The building is designed to give plenty of room around the machinery, and is well arranged as to the general mechanical lay-out.

The turbines are of the Westinghouse-Parsons type of 500-kw. capacity, and are direct-connected to three-phase 60-cycle, 2,300 volt Westinghouse generators. There are two machines in the original design of the plant, and sufficient room has been provided for future additions in both the turbine room and boiler room.

There are two exciters, one steam and one motor driven, each of 60-kw. capacity and arranged so that either may be used at will. The stream-driven machine is direct connected to a standard Westinghouse engine, and the motor-driven unit is direct-connected to a three-phase 60-cycle motor.

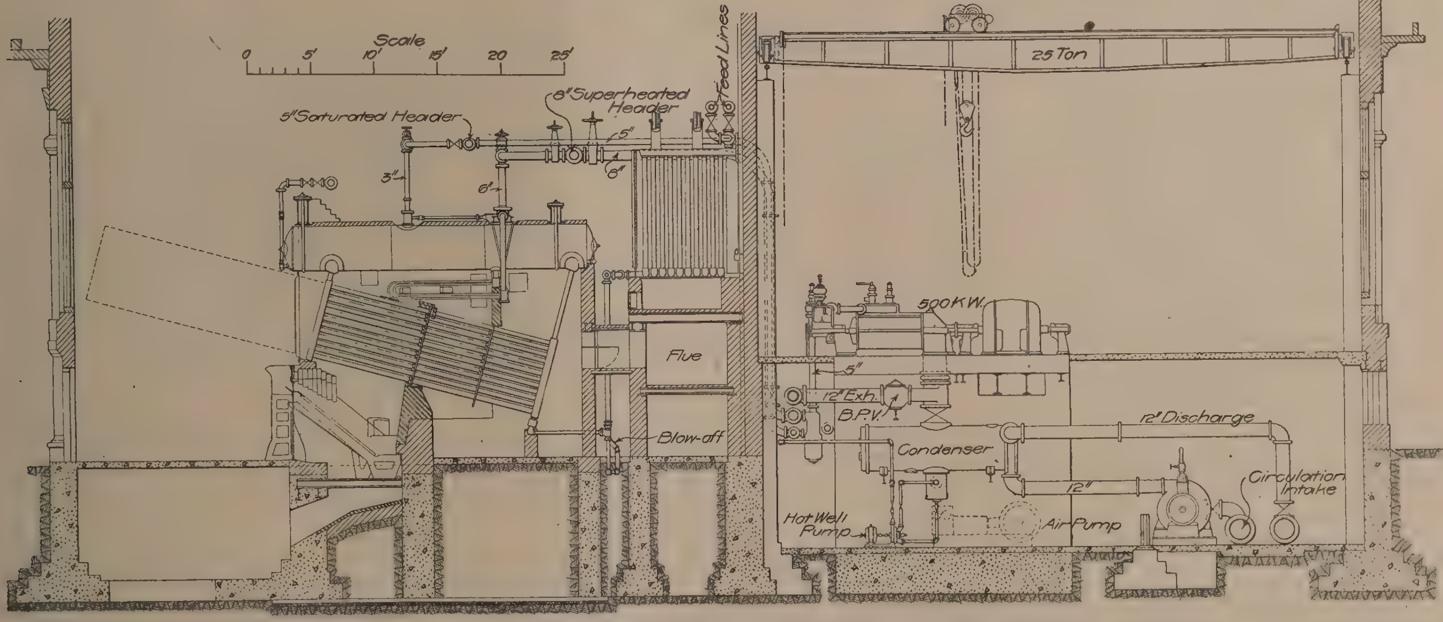
Under each turbine between the foundations is placed a Worthington surface condenser. Each condenser has 2,400 sq. ft. of cooling surface, in order to maintain 28 in. of vacuum with a 30-in. barometer, with condensing water entering at 80°. Each condenser is fitted with inner air coolers, to which the rotative dry vacuum pumps are connected. The vacuum pumps are Worthington make, 6 x 12 x 12 in., and arranged so that either pump may be operated with the opposite condenser.

Underneath each condenser and connected to the hot well, there is a Worthington 1½-in. two-stage turbine pump direct-connected to a three-phase induction motor for pumping out the condensed steam. These pumps discharge into a large hot well from which the boiler feed water is taken.

The salt condensing water is brought in from the sea through 20-in. cast-iron pipe by a 10-in. Worthington centrifugal pump direct-connected to a Westinghouse engine. The water after passing through the condensers is returned to the sea in a similarly arranged 20-in. pipe and discharged below low-tide surface in order to get the advantage of the syphon effect.

The condensing water is brought to within 200 ft. of the plant through an open concrete canal of about 80 ft. cross-section area, which begins at deep water, about 2,000 ft. distant, and terminates in a large circular basin from which the 20-in. pipe takes the water.

Gulfport Power Plant.



Cross-Section of the Power Plant of the Gulfport and Mississippi Coast Traction Co.

The present boiler capacity of the plant is 1,038 b. h. p., made up in three units of 346 h.-p. each, set in one double battery and a half battery with the necessary foundations and openings for a future boiler of the same type and capacity. The boilers are Babcock & Wilcox make, with wrought steel headers, and are capable of carrying 200 lb. steam pressure. Each boiler is fitted with the standard Babcock & Wilcox superheater arranged so that superheated steam can be taken off independent of saturated steam. The boilers are fitted with Roney stokers and arranged with overhead coal bunkers having a capacity sufficient for a 48-hour run.

The coal and ashes are handled by Jeffrey coal conveying machinery, fitted up with coal crushers and the necessary automatic machinery to reduce the manual labor to a minimum. The ashes are run from the furnaces by gravity through ash hoppers into the basement underneath the boilers and there taken up by the conveying machinery.

Back of the boilers are the Green fuel economizers. These are arranged so that the gases from each boiler can pass through or go around the economizers to the stack. The Custodis stack is 8 ft. in diameter and 175 ft. high and connected to the boilers with brick breeching.

There are two Worthington boiler feed pumps, 12x7x10-in., of the packed plunger pattern, and built for 200 lb. pressure. The pumps were selected of large size in order to be able to handle the feed for the total plant after it has increased to double its present capacity. The pumps are arranged in tandem and connected so that either may be operated at will.

In the pump discharge there is a Goubert closed heater of 1,800 h.-p. capacity. The heater is direct-connected to the main exhaust header and arranged so that the exhaust from the auxiliaries passes through it at all times. In case the turbines are running non-condensing, their exhaust will also pass through the heater.

The pipe system is laid off in two separate and independent lines for superheated and saturated steam respectively.

The superheated steam line is fitted at each boiler with a Foster automatic and hand stop emergency non-return valve, and these valves are so arranged that through a pilot valve they can be closed down instantaneously from either the firing floor or turbine room, making the steam lines absolutely under the control of the engineer.

From these valves the main steam header is connected by long radius bends. There is a large header running the full length over the boilers and near the center and at one end this header is branched off and run to the basement below the turbine room floor. The two branches run into a secondary main header which is hung from the basement ceiling and at convenient points the branches are taken off for the turbines. On each branch to the turbines is placed a Stratton steam separator to prevent any water of condensation from being carried over to the turbines on starting up. Both the main header and subheader are arranged with fittings and blank flanges so that future extensions can be made without causing any serious delays.

All flanges on the superheated steam header are Van Stone slip joints. One point regarding this line is of interest; the line is fitted up with Goetze corrugated copper gaskets and during one year's continuous operation, there has not been a joint that has required attention.

The saturated steam header is run similar to the superheated steam header, but not fitted with automatic stop valves. The same design of a main header over the boilers and a sub-header in the basement is carried out, and from the header in the basement branch lines are run to all auxiliary machinery which is placed in the basement. Steam for the boiler feed pumps is taken off the main header over the boilers. A reducing valve is placed near the main header, on the branch connecting the main and sub-header, in order to reduce the boiler pressure from 160 to 100 lb. for the auxiliaries.

From special tees under each turbine, the atmospheric exhaust branches are run. In each branch at the tees is placed a Blake automatic exhaust relief valve. Each branch runs into the main exhaust header, thence to the heater and outboard exhaust, terminating with a Swartout exhaust head.

The three main headers in the basement are suspended from the turbine room floor underneath each other. The hangers for these are made up with turnbuckles so that each header is independent of the other.

The feed pumps are piped up so that water can be taken from a large hot well placed in the basement, into which the condensed steam from the turbine flows, or through this hot well the boiler water can be obtained from a natural flowing artesian well, which furnishes an abundance of water if the plant should be run non-condensing. By means of a float valve, water from the well is added for make up.

The discharge for the feed-water lines is arranged so that the heater and economizers can be run at the same time or separately, or the pumps may deliver direct to the boilers cutting out both the heaters and economizers.

All fittings for steam lines and feed water lines are Crane's extra heavy flanged fittings, the valves are Chapman make, extra heavy where required, and designed for the different types of service. Live steam lines and feed water lines are covered with 85 per cent. Keasbey & Mattison magnesia covering, and exhaust lines with asbestos air cell covering.

All pipe work in the boiler room is suspended from the roof trusses by adjustable rods, and in the basement from the ceiling.

The circulating pumps are primed by the rotative dry vacuum pumps through a 2-in. pipe which connects to the highest point of the circulating system and runs to a point about 34 ft., above this and thence down to the pump. The priming pipe has this high loop in it to prevent salt water from being drawn over into the pumps. It requires about fifteen minutes to prime the pumps by this method when there is no water in the system. There is no foot valve on the 20-in. main suction pipe.

The only feature about the piping of the auxiliary machinery that requires mention is the by-pass connection on the rotative dry vacuum pumps. These pumps are connected so that either pump may be operated with either condenser.

The generators furnish 2,300-volt, 60-cycle, three-phase current. From the generators it is conducted to the main switchboard and through generator panels to the 2,300-volt busbars. Part of this current is then taken through step-down transformers from 2,300 volts to 380 volts and fed to the alternating current end of two 200-kw. rotary converters, being converted to 550 volts direct current. This 550-volt current is fed direct into the trolley circuit. Another portion of the 2,300-volt alternating current from the high voltage busbars is fed into the primary lighting circuit, extending through the city of Gulfport and also into the transmission line which extends both ways from Gulfport to Biloxi at one end and Pass Christian at the other end. This high-tension circuit is constructed of bare aluminum stranded wire of about 75,000 c. m. cross-section, and is designed to supply the intermediate lighting service along the coast between Pass Christian and Biloxi.

Another portion of the 2,300-volt current is conducted through step-up transformers and raised from 2,300 volts to 13,200 volts alternating current. This is conducted on a high-tension transmission line, constructed of three bare aluminum stranded wires of about 50,000 c. m. cross-section to the sub-stations located at Biloxi and Pass Christian, Miss., where it is reduced through step-down transformers to 380 volts and 2,300 volts alternating current. The 380-volt current is carried direct to the alternating current end of two 200-kw. rotary converters similar to those at the main station. The 2,300-volt current is used for lighting service in the two towns. Both the 2,300-volt and the 13,200-volt transmission lines are three-phase and constructed in triangular form with 36-in. separation of each leg.

The pole line is constructed of 35-ft. creosoted poles, with creosoted cross arms, 11-in. locust pins and Locke high-tension insulators. The trolley circuit consists of two 4/0 grooved lines in parallel with 6-in. separation between running wires and is hung on a 9-ft. Richmond flexible bracket, 20 ft. above the rail. This trolley circuit is designed to furnish ample capacity in the trolley wires without carrying an additional feeder to reinforce the line. High-tension transmission lines are protected at intervals and at both main station and sub-station with low-equivalent lightning arresters, manufactured by the Westinghouse Electric & Mfg. Co. The system is arranged with disconnecting switches at both sub-stations and main station, so that it is possible in case of emergency to feed the rotary converters at both sub-stations through the 2,300-volt line, this giving in a measure a duplicate transmission line.

The rotary converters to be used on this system are designed to start with a small motor mounted on the end of the main armature shaft, this doing away with the violent fluctuations in the line when starting the rotary converter from the alternating current end.

The plant has been in operation about twelve months and in every respect given entire satisfaction. The turbines have been run as long as four months continuous without showing any defects at all, and carrying 50 per cent. overload without trouble. The condensing apparatus has maintained 27½ and 28-in. vacuum at all times without the least strain and the boilers have given entire satisfaction, and in every case responded to over-load peaks without undue strain.

After twelve months of operation, the demand for electric current has exceeded the capacity of the plant so much so that at present the company has signed contracts for the installation of one 1,500-kw. Westinghouse turbo-generator, the necessary auxiliary condensing machinery and additional boiler capacity. The present building will accommodate all of this, anad the installation will be easily made, as all preparations were made for extension in the original designs.

The electrical part of the plant was installed by the Westinghouse Electric & Mfg. Co., under the supervision of Mr. F. D. Gatchell, and the boilers, auxiliary machinery and pipe work were laid out and installed by A. M. Lockett & Co., Ltd. of New Orleans, La., contracting mechanical engineers. The contracts for the new machinery have also been given to these companies.

Care of Electric Railway Tracks.

A paper presented to the American Street and Interurban Railway Engineering Association by George L. Wilson, Engineer, Twin City Rapid Transit Co.

Interurban Track.—The conditions of the interurban roads located, as all such roads should be, on a private right-of-way, approach closely those of steam roads. Many of the methods used in steam road practice, as the result of years of experience, are required for electric roads.

Grading, ballasting, construction of bridges, culverts and crossings, care of roadbed and track follow the same lines. The standard works of reference on these subjects apply with slight modifications to the care of electric roads and should be diligently studied by those in charge of permanent way.

The maintenace of the earlier and cheaply built electric roads has demonstrated that it is economy to have electric roads built with well-ballasted track; ties and rails put in as perfect condition, in regard to surface and alignment, as possible. Then the object in view is to preserve them in the same condition.

Following the purpose of keeping the track in perfect condition, which includes drainage, care of switches, crossings and side-tracks we come to the care of the right-of-way, cleaning from snow in winter, maintaining fences, public crossings and the making of the company's property attractive to the passengers.

It should be remembered that the principal business of electric roads at present, and probably for a long time, is the transportation of passengers, whose comfort and interest are constantly to be kept in mind.

The removal of rubbish, weeds and unsightly objects of all kinds, including advertising signs, from the vicinity of the tracks is a proper part of the care of the roadway.

Company property should be neatly arranged when stored, and the land owned by the company along the line and at stopping places ornamented with grassy slopes, vines and shrubbery.

At terminal or waiting rooms there should be flower beds and grass plots, instead of ragged grounds and piles of debris. Otherwise, waste grounds can be so improved that there is something of interest to attract the passenger's attention at every point.

This is looking some distance ahead for new lines, but it is practical to do a little, month by month, and year by year, until the right-of-way becomes a boulevard or parkway.

All passenger transportation lines find it desirable to make their routes as attractive as possible. A sloping hillside cut may, by the proper planting of shrubs, be made beautiful, with their flowers in summer, and gorgeous with the autumnal foliage. A rocky bank is not of itself attractive, but partly covered with vines it becomes an interesting feature.

Steam suburban roads have done considerable along this line, and the lot of the commuter has been cast in pleasant places thereby. The great trunk lines of the country are working to the same end. Through the Eastern States many of the roads pay a great deal of attention to the making of their station grounds attractive. The annual circular of a transcontinental line offering cash prizes to its station agents for the best station flower gardens is attractively illustrated and directed to "Our Fellow Workers among the Flowers."

The aim of every electric road must be to have its patrons attracted and interested along the way, that the route may seem both short and pleasant and the trip one to be repeated.

With the care of interurban track it is proper to consider the men as well as the roadway. The growth of railroads, both steam and electric, has required more men than are to be found in the track crews. It is a fact that track labor has been recruited from the lowest paid classes, with the result that ambitious workmen have largely gone into other lines.

Our first railways and public works generally were built by the sturdy Irish immigrant, who rose soon to more remunerative employment. To-day the mass of employes have no apparent interest in, or regard for, the quality or amount of work they perform. In many cases the foremen and officials can only communicate with them through interpreters, and there is an absolute lack of loyalty to the interest of the employers. This must be changed if the best results are to be obtained.

It is not necessary that a track crew should be skilled mechanics, but if track, switches, frogs and all appliances are to be in the best working order men of a fair amount of ability and some mechanical skill are required.

To obtain this end the conditions must be such that an intelligent laborer can make a decent living and have a steady income. Work should be planned so as to be distributed through the year as far as possible, in order that there may be constant employment for a nucleus of good men.

Let the men from bottom to top have an interest in the results of their work and in the efficiency of the section or division where they are employed. Make them feel that it is their company and that they are a part of the whole machine. The question of keeping skilled laborers who will do good track work is at the bottom of the maintenance of track and the most difficult problem.

All interurban track should be patrolled daily, at least, and this brings us to the track-walker and his duties. This position is above that of laborer and next to that of foreman. A skilled trackman who is sober and industrious and who can be depended upon to see that splices and bolts are in adjustment, drains and culverts open, who will detect any spreading track or broken rails, see that farm gates are kept closed and stock off the track, in fact, be a general inspector and caretaker, is an important person. It is in a great measure to his fidelity that the safety of cars and passengers will be due.

City Tracks.—On city tracks the care of the roadway, besides the keeping of rails, switches and curves in good order, includes more or less of cleaning, sprinkling and snow removal. In order to determine the practice of different companies and for a guide for future operation, inquiries on these subjects were sent to fifty leading companies. Fom their reports the following notes have been prepared:

In the matter of cleaning the space occupied by tracks on paved streets the general practice is that the municipality bears the entire expense, as the theory is that the cars do not bring dirt onto the street, and the cleaning of the entire paved roadway would have to be done and the expense borne by the city if there were no tracks.

The fact of the tracks being in the street does not entail additional expense on the city. This view has been upheld in the courts, and it appears that refuse and things left on the streets by pedestrians, teams and by storekeepers, who often dispose of litter by throwing or sweeping it into the roadway, should be taken care of by the city authorities. Inquiries on this subject were made of fifty companies in all parts of the country, and of forty-six replying and operating 8,469 miles of track, with a tributary population of 13,241,000, it appears that forty-one, operating 6,706 miles of track, pay no part of the street cleaning expense.

In a few cities the railways bear a part of the street cleaning expense, this being done either voluntarily or by charter requirement. In these cases it should be considered as a contribution or a part of the amounts paid in by way of taxation.

The following are among the prominent companies which assist the cities in this matter:

Chicago Union Traction Co., Chicago City Railway Co. and South Chicago City Railway Co.; cost $123.60 per mile for cleaning and sprinkling in 1906.

Columbus.—On 79 miles of single track, within city limits, partly on unpaved streets, cost for cleaning and sprinkling was $13,000 in 1906; cost per mile of single track, $164.55.

Pittsburg.—Company pays for proportional part of street occupied by tracks.

New Orleans.—Pays for sweeping one street only.

New York City.—Pays for sweeping Broadway only, from Bowling Green to 15th St.

Twin City Rapid Transit Co.—Pays for sweeping its track allowance in St. Paul and Minneapolis; 86.12 miles of single track in 1906 cost $23,475.55; cost per mile, $272.56.

As street sprinkling is found to be carried on satisfactorily by sprinkling cars, it is believed that the cleaning of the track allowance can be done economically and satisfactorily with sweeping machinery which will take up the debris, place it in a receptacle and take it away to proper dumping grounds. This is an important subject for the companies which pay for cleaning their track allowance.

In the large majority of towns the street sprinkling is taken care of by the municipal authorities, without reference to the street railways, no part of the expense being paid by the companies. Returns from 24 companies, operating 4,768 miles and having a tributary population of 10,156,000, show this condition: Companies operating 3,356 miles sprinkle tracks only with tank cars; of these the practice is so mixed that it is difficult to know how much mileage is sprinkled. In general, it appears that the more important streets are the only ones sprinkled. This is done under requirement of state law or city ordinances. The cities are required to furnish water without charge, though in some places the company is obliged to pay for the water—in one case 6 cents per mile of track.

The business of sprinkling the whole of the roadway from tank cars has been developed to quite an extent; one outside company owning cars makes contracts with cities for sprinkling the roadways, and has 250 miles of streets covered. The railway companies operate the cars for a price per car-mile. The authorities of the cities report that the service is very satisfactory. The railway officials report that this plan gives good results and, while the returns are small, the conditions, on the whole, are satisfactory.

A number of cities pay the railway companies directly for this same kind of service. Prices received by the company for this work vary from 7 to 17 cents per car mile, 10 cents being about an average. The cost to the property owners per season is about 10 cents per foot of street, or 5 cents per front foot.

The tank cars used are of a variety of types, from the plain rectangular box to the cylindrical sheet iron tanks, operated either directly by gravity or as pneumatic sprinklers, having the tank under air pressure. The capacity is from 2,500 to 6,000 gal.

Four thousand gallons will sprinkle some six miles of tracks or three miles of entire roadway. Any statements of this kind are rather indefinite, depending upon so many conditions. A better idea of the work done is to say that in actual practice one car making four trips per day will care for eight miles of street.

While the returns for the service are small, the indirect benefits are of as much or more value. The freedom from dust not only decreases the expense of repairs to car machinery and gives a better contact between rail and wheel, but also, by more comfortable conditions for passengers, increases the pleasure of riding and other traffic so much that managers consider the expense more than met by increased revenue.

The use of oil for laying dust on some streets and for the roadbeds of railways has been extensively advocated. It has been tried by a number of roads. Some consider its use satisfactory, but the greater number have not put it into extensive use. The heavy asphalt oils of California appear to give the best results, while in the Central and Eastern States a so-called "roadbed" oil prepared by the Standard Oil Co. has been used more or less experimentally for ten or twelve years.

Among the steam roads that have used oil are the Boston & Maine, Boston & Albany, Central Railroad of New Jersey, Long Island Railroad, Delaware & Hudson, Santa Fé, Chicago, Burlington & Quincy, Oregon Short Line, Chicago & Alton and the Southern Pacific, the last the most extensively, having used it for five or six years on about 900 miles of road.

In practice the roadbed is sprinkled with about 2,000 gal. per mile for the first application. After the first dressing the quantity may be lessened to 600 or 1,000 gal. per mile annually, though some parties claim that two applications annually are needed. The sprinkling appliances used and the process are claimed to be controlled by a Chicago firm, which charges a royalty of $10 per mile for its use for the first application, no charge being made for subsequent sprinklings.

Few electric roads have used oil. The Los Angeles Pacific reports its use on unpaved city streets and states that three coats per year are desirable. At 60 cents per barrel, the cost per mile of double track is $100. San Francisco reports its successful use on macadam streets outside the city limits. The Brooklyn Rapid Transit Co. is experimenting with 20 miles of track on its suburban lines on private right-of-way where the pleasure riding is very heavy and the roadbed of sandy material.

From the reports of roads using oil it appears that managers of the steam roads, at least, do not consider its use profitable, and there is no general movement to adopt it. On electric roads on private right-of-way or on macadam outside of built-up sections of cities it may prove to be economical where the oil is obtained at a low price, especially on sandy roads leading to pleasure resorts. The accompanying memoranda in regard to the practice and cost may be of interest:

Boston & Maine R. R.—Has used oil in 1890; covered about 400 single-track miles; uses 2,000 to 3,000 gal. per mile; price of oil, 2.75 cents per gal.; average cost, $100 per mile.

Boston & Albany R. R.—Made experiments for three years, 1898-1900; used 2,000 gal. per mile first year, 600 gal. second year, 1,000 gal. third year; cost per gallon, 2.75 cents; cost per mile of track, $80.

Central R. R. of New Jersey.—Will use oil on Sea Shore Line for dusty season; uses apparatus constructed at its own shops; pays a royalty for the process.

Long Island R. R.—Use oil on crossings; cost, $125 per mile; use 600-gal. tank cars; oil costs 2.4 cents per gal.; 600 gal. used per mile; results on cinder and gravel ballast satisfactory.

Delaware & Hudson R. R. Co.—From 1896 to 1900 oiled road from Saratoga to Plattsburg, 188 miles; used roadbed oil prepared by the Standard Oil Co.; price, 2.75 to 4.75 cents per gallon; for 2,000 gal. per mile cost was $100; kept dust down, but its use has been given up; 1,000 gal. per mile every other year would be sufficient.

Oregon Short Line.—Reports using a little oil on a branch line, which kept down dust till track was ballasted.

Brooklyn Rapid Transit Co.—Reports that some track on private right-of-way has been sprinkled for two years; will sprinkle 20 miles in 1907; results satisfactory.

Chicago & Alton R. R. Co.—Use crude oil at 3 cents per gallon for sprinkling road crossings only; stone ballast on rest of road and does not need it.

Southern Pacific R. R. Co.—Has used oil for five or six years; 900 miles of track oiled; may use up to 4,000 gal per mile; pays $10 per mile royalty.

San Francisco Electric Railway Co.—Uses oil on macadam streets, but not inside city limits.

Los Angeles Pacific Co.—In Los Angeles on unpaved streets an occasional coat of oil is applied; generally, oiled streets are sprinkled three times per year; cost, $100 per mile of double track.

The universal practice with reference to snow is to keep the tracks open for service by the use of plows and sweepers during and immediately after each snowfall. The snow thus deposited on the rest of the roadway is left, as far as it can be done, without impeding travel. At crossings and congested points in business districts all companies assist in removing snow as promptly as possible by the use of car and team.

When it is necessary to remove snow from roadway the companies generally pay the cities one-third or one-half the expense incurred on the whole street. In some cases the cities and railway companies divide the streets, the railways taking care of a sufficient number of them to make up the same area as their total track allowance. One company takes one side of the streets and changes sides annually. This is reported as working well in a city of 60,000 people.

In many cities no separate account of this expense is kept, and, owing to the fact that conditions vary so widely between Southern and Northern locations, no satisfactory comparison of costs is practical.

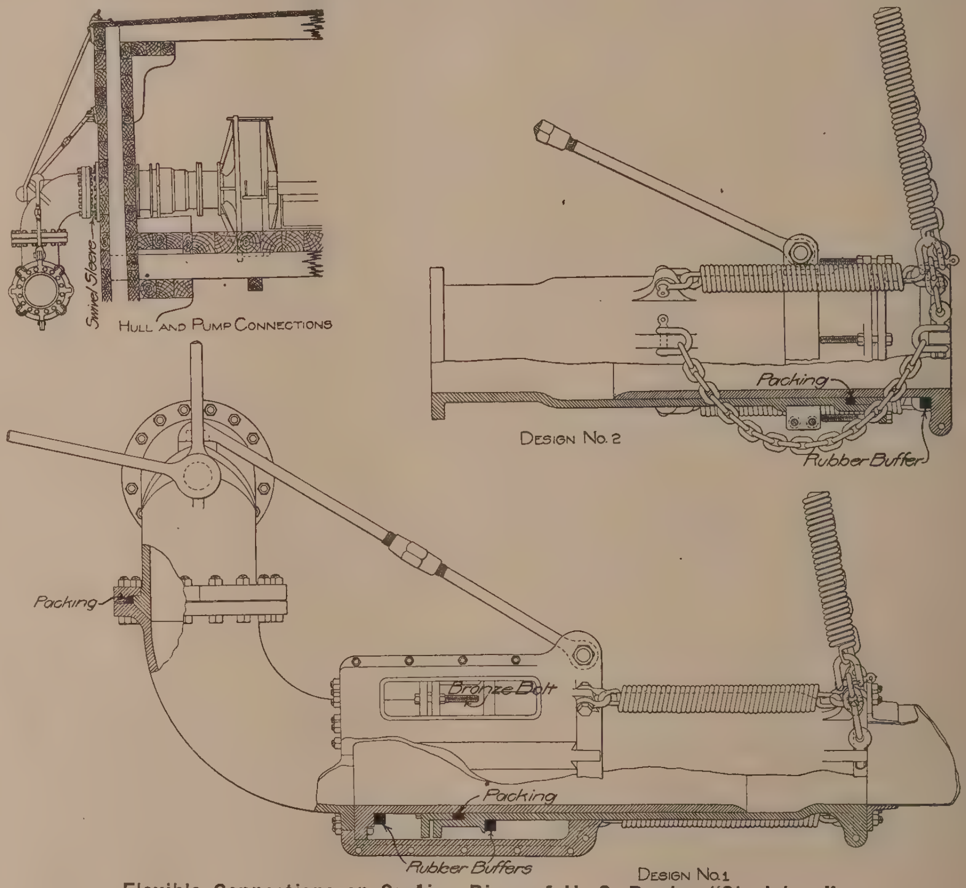
Figures given show results of $17.41 per mile of single track in a city of 175,000, with 140 miles of track, in the Central States for an average winter. In Chicago, 1906-'07, the cost was $41.13 per mile of single track for the Chicago City Railway Co., while in Milwaukee, 85 miles away, but a very small expense was incurred. Another lake city, Detroit, reports $35 per mile for an average winter. Duluth gives $45.45 for an average winter. Toronto reports on 98 miles of single track in 1904-'05 a cost of $102.04 per mile for one-third of street area. Providence, R. I., reports a cost of $148 per mile of single track in 1906 and 1907. Here all snow over 4 in. deep is removed.

DEFLOCULATED OR ACHESON GRAPHITE remains indefinitely suspended in machine oil, and in consequence some engineers are turning their attention to its special uses as a lubricant. Prof. C. H. Benjamin states in the "American Machinist" that he has found the effect of adding deflocculated graphite to oil to be very noticeable. He has made many tests with such a mixture and with the same oil used alone. With one or two exceptions, the addition of the graphite has at once reduced the friction and increased the life of the lubricant. The graphite improved all the varieties of mineral oils which were tried. One-third of 1 per cent. of graphite was tried with two grades of oil under different loads and reduced the coefficient of friction with the better oil about 20 per cent. and with the poorer oil about 23 per cent. One-sixth of 1 per cent. of graphite had a slight effect in reducing the friction of a standard engine oil, and this is apparently about the minimum quantity that can be used with any advantage. It also seems from his tests that the use of this grade of graphite with water has a tendency to prevent rust.

A New Flexible Connection for Suction Pipes of Dredges.

The expense, delays and inefficient service attending the use of rubber suction hose in the suction pipes of sea going suction dredges for the purpose of providing a flexible connection between the rigid portion of the suction pipes, which trail along the bottom being dredged, and the hull of the dredge, have been very detrimental to the successful operation of these vessels.

The rubber hose for an 18-in. suction pipe costs about $500, not including the cost of the flanged nipples and other fittings attached to the hose. While occasionally these sections of hose render service for several months they frequently fail within a few weeks. The inner tube or lining often becomes detached from the walls of the hose within a short time and the contraction of the hose, under the usual vacuum of 25 in., constricts the passage, and the usual irregularities increase the friction so much that the maximum efficiency of the pumps can rarely be attained. When the hose begins to leak it generally has to be replaced at once with another one. It often happens that several sections of hose fail within a short period of time, and unless an unusually large supply is on hand to replace them the work of the dredge may be delayed several weeks awaiting a new supply. The material of which the hose is constructed deteriorates rapidly, especially in warm climates, hence the inadvisability of keeping a large supply on hand.



Flexible Connections on Suction Pipes of U. S. Dredge "St. Johns."

The device shown in the accompanying drawing was designed to replace the rubber hose and obviate its disadvantages.

The usual swiveling sleeve in the line of the suction pipe leading from the pump, passing through the side of the vessel and made air tight by a stuffing box, is made use of in the customary manner. To the outer end of this sleeve is attached an elbow of 90 deg., which in turn is connected to another elbow of 90 deg. by a swiveling joint of special construction which is self-explanatory on the drawing. To the latter elbow is attached a telescopic section of pipe which may be arranged either as shown in Design No. 1, or in Design No. 2, on the drawing. The movement of this section of pipe within itself is under the control of springs as shown and responds to torsional as well as longitudinal stresses. The normal position of the pipe when at rest is as shown on the drawing. Under tension it has a maximum extension of 14 in., and under compression, as when the vessel retrogrades while the drag is on the bottom, as some times occurs, this section of pipe can collapse 8 in. from the position shown on the drawing, or a total of 22 in. from extreme extension. It will be seen that this device permits the drag to accommodate itself to irregularities of the bottom and to change its relative position with respect to the vessel as the demands of practical work require, without bringing undue stresses upon the several portions of the pipe or upon the vessel. In practice it has been found that it meets the conditions imposed much better than the rubber hose.

The dredge "St. Johns," which has two 18-in. dredging pumps, had one of these connections of Design No. 1, on her port suction pipe when she began work on the shoals at the entrance to the St. Johns River, Florida, Oct. 20, 1906. Another connection of Design No. 2, was put in service on the starboard side on April 12 of this year. No repairs whatever have been required to either connection and no delays have in any wise been occasioned by them. The swivel joints of both connections have required no attention since they were installed, and remain air-tight. The stuffing box of the telescopic portion of the first connection has been repacked once, the other not at all. During the time between the installation of the first connection and that of the second, four sections of rubber hose were worn out on the starboard side. During the period from Oct. 20, 1906, to July 1, 1907, this dredge removed nearly 500,000 cu. yds. of ocean drift sand and carried it to sea an average distance of 3.6 miles. From May 16 to June 15 of this year, during which time the weather did not materially interfere with the work, the dredge removed 96,028 cu. yds. Work was done with one crew and was carried on during the daytime only.

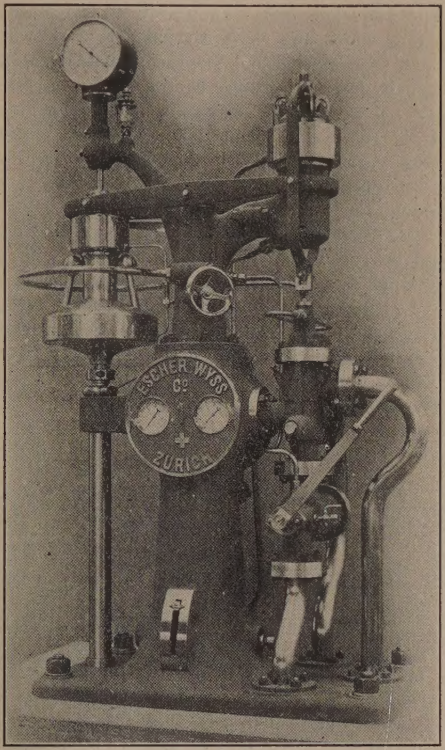
A ball-and-socket joint is now being used on some sea-going suction dredges in place of the rubber hose. As compared with the connection here described, the ball-and-socket joint appears to have the following disadvantages: The joint being rigid longitudinally, severe stresses are brought to bear upon the pipe and its connections when the drag encounters unusual obstructions in the bottom, or when the vessel settles backward in a sea-way while the drag is down. In order to provide the latitude of motion required in practice, as when transverse winds or currents prevail or when the vessel suddenly changes its direction for any reason, the ball-and-socket joint must be of large cross-sectional area or the passage will be constricted when the pipe is near its limit of transverse motion. This produces a considerable irregularity in the passage, causing an interference with the free flow of water through the connection If, through inattention, the pipe is permitted to swing, with respect to the vessel, beyond the limit afforded by the ball-and-socket joint, the joint or the pipe or both are apt to be broken. Such contingencies have occurred and the accidents mentioned have resulted in practice. The lower position of the suction pipe, where it connects with the swiveling elbows, in the device here described, permits the pipe to swing somewhat farther under the turn of the bilge of the vessel without damage than with the more direct alignment given by the ball-and-socket joint.

The device is original with Mr. J. A. Sackett, chief assistant engineer to Major Shunk, U. S. Engineer Officer in charge of the Florida district, and he designed all the details of the completed apparatus.

A LARGE ICEBREAKER has been recently launched at the yards of Sir W. G. Armstrong, Whitworth & Co., Ltd., England. This vessel, which was built for the Government of Finland, is 220 ft. long, 47 ft. wide and 28 ft. 2 in. deep. She has a propeller at the bow as well as at the stern. The forward propeller gives increased maneuvering power and assists in the breaking of ice by disturbing the water under it.

Large Impulse Wheels for a Brazilian Hydro-Electric Station.

The Rio das Lazes hydro-electric station of the Rio de Janeiro Tramway Light & Power Co., which is to have an initial installation of 54,000 h.-p., consisting of six 9,000-h.-p. units, was referred to briefly in The Engineering Record of Aug. 17, 1907. Since then, Mr. R. Weber, formerly chief engineer of the Escher, Wyss & Co., of Zurich, Switzerland, under whose direction the water wheels were designed and built, has furnished the accompanying views of one of the 9,000-h.-p. wheels set up in the shop, and of the automatic governor furnished for each wheel.



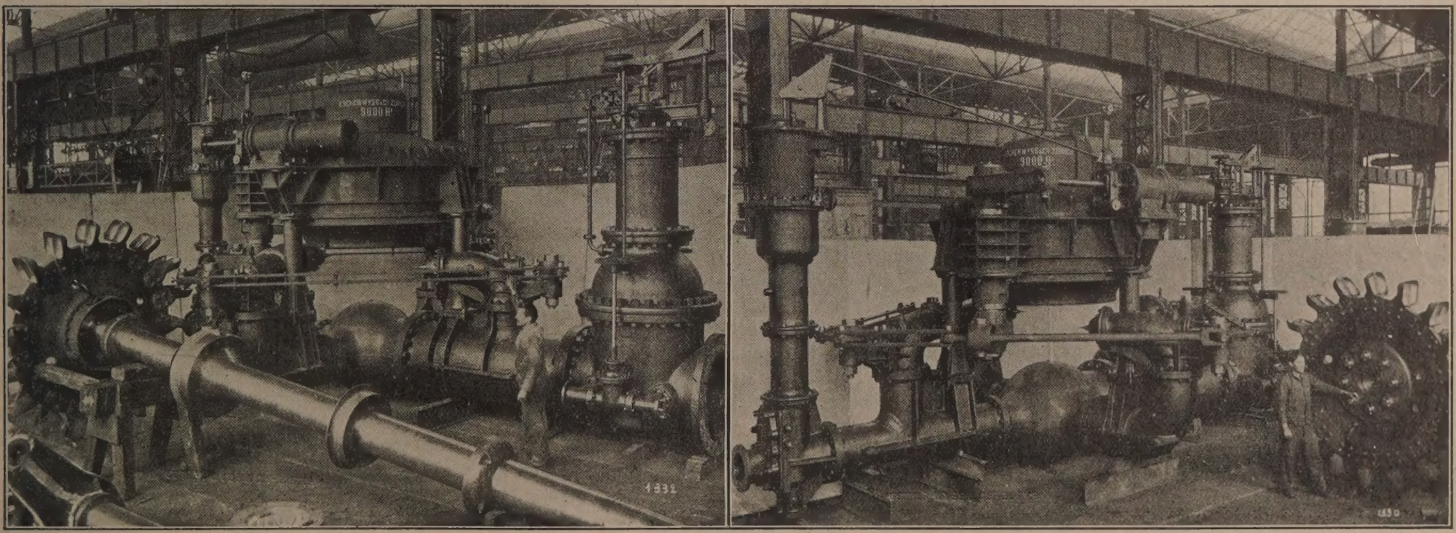
Governor for Impulse Wheel.

A concrete dam, 115 ft. high and 92 ft. thick at the base, was built at a series of falls on the Rio das Lazes, 56 miles from Rio de Janeiro, to develop a storage reservoir for the station. Two 8-ft. riveted steel supply lines, about 6,000 ft. long, lead from this dam to a cross receiver near the power house; a 12-in. and six 36-in. pipes extend from this receiver to the station, at which the total head varies from 950 to 1,000 ft. These pipes are all of welded-steel plates; the thickness of the plates for the 36-in. pipe varies from 0.4 to 0.7 in. and that of the 12-in. pipe from 0.25 to 0.3 in., depending on the head. The receiver is connected with a small service reservoir at the same elevation as the main storage reservoir, this small reservoir acting as an equalizer to maintain and regulate the flow in the supply lines.

At the power house each 36-in. pipe line connects with the penstock of a 9,000-h.-p. vertical-shaft impulse wheel. The 12-in. pipe connects to the penstocks of two 500-h.-p. horizontal-shaft impulse wheels. The main wheels are each direct-connected to a revolving three-phase 50-cycle 6,000 h.-p. Westinghouse generator, the units being designed to operate at 300 r. p. m. The 500-h.-p. wheels are each direct-connected to direct-current generators, which supply excitation current to the main units and operate at 500 r. p. m.

Each main wheel has four variable-orifice needle nozzles through which water is supplied to the runner of the wheel. The operation of these nozzles is controlled by a special type of oil-pressure governor of the fly-ball type, which was designed by Mr. Weber. This governor is geared to the shaft of the unit, and actuates a valve in a pipe supplying oil to a cylinder that directly controls the position of the needle nozzles. Each wheel is also provided with a relief valve which is connected to the governor in such manner that it is only opened when all, or a relatively large percentage of the load on the generator suddenly drops off. Dependence for speed and pressure regulation is placed entirely in the governor and the relief valve, respectively, as the nozzles are not deflected. The whole arrangement is therefore water saving, since the relief valve is wasting water for a few seconds only when the load is decreasing rapidly.

The field of each 6,000-h.-p. generator being mounted on the same shaft as the runner of the wheel, each unit has but two steady bearings, the field being on an overhang of the shaft at the top and the runner on an overhang at the bottom. A maximum thrust of about 100,000 lb. is developed in each unit, and is carried by a thrust bearing of the oil-pressure type. This bearing is located between the two steady bearings, oil being supplied to it at a pressure of about 150 lb. The oil required for this bearing, and that necessary to operate the governing mechanism is supplied by a pump to each unit. These pumps are each driven by a small impulse water wheel.



Two Views of Impulse Wheel of Nine Thousand Horse-Power Capacity.

The wheels of the main units have a guaranteed efficiency of 82 per cent. at full load. The governor is guaranteed to prevent a speed variation of more than 10 per cent. when the full load is suddenly thrown off, the difference in speed between full load and no load being only 2 per cent. The relief valves will prevent an increase of more than 3 per cent. in the water pressure in the penstocks.

The runners of the impulse wheels of the exciter units are mounted on an overhang of the shaft of the direct-current generators. Each of these wheels has a single needle nozzle, controlled by an oil-pressure governor similar to those for the main units.

A Machine for Tunneling in Shale.

Numerous attempts have been made from time to time to build a machine which could be used to bore tunnels through rock without requiring explosives. While a small machine for this purpose has been reported to be operating successfully in Colorado, so far as this journal has been informed no such machines of any size have ever delivered satisfactory results in actual service. The latest attempt to perfect a machine to bore a fair-size tunnel has recently been abandoned, although the mechanical defects to be overcome were apparently not insurmountable. The Engineering Record has been supplied with considerable data concerning this machine, which are presented herewith, although no information regarding the place where the machine was tried can be made public.

This particular machine was designed to operate on the principle of a stone planer. The tunnel in which it was set up for a trial is being driven through shale rock. It has a finished diameter of 8 ft. and is lined with 12 in. of concrete. The machine consisted essentially of a 10-ft. cylinder, 48 ft. long and built of steel plates, carrying a revolving disk at the front end to which were attached the planer knives, or tools, the driving machinery being distributed through the cylinder. The disk at the front end of the machine was mounted on a hollow steel shaft, 4 ft. in diameter and about two-thirds the length of the cylinder, contained in the latter. This shaft was concentric with the cylinder and turned in two heavy bearings, one toward each end of the cylinder, which were carried by heavy frames attached to the steel shell.

Four 65-h.-p. electric motors in the cylinder, operating at 500 r.p.m., drove the shaft at a single revolution per minute through a set of gears. The front end of the revolving disk on the forward end of the shaft had six very heavy cast-steel arms radiating in the form of a flat truncated cone from a hub at the center. The planer tools were attached to these radiating arms. These tools were made of a special grade of tool steel and each had a cutting edge about 2 in. wide. They were pitched about 2 in. apart so the 2-in. annular cuts made by them were separated by 2-in. rings of stone that were not planed off, but broke away as the cuts were made on both sides of them. The tools were so placed at different angles with the arms which carried them as to facilitate the cutting with the smallest amount of power. The face of the bore was taken out in the form of a truncated cone of the same pitch as the arms carrying the tools, and with a uniform diameter of 10 ft. 4 in.

The rock as loosened by the tools varied from a small amount of fine dust to pieces 6 to 8 in. in their maximum dimensions, the majority of the muck being about an average between these two extremes. The loosened material was picked up by buckets attached to the rim of the disk, and delivered to a traveling conveyor-belt that extended through the hollow shaft carrying the disk, to the rear end of the machine. These buckets radiated from the center and extended through the rim of the disk. Some of the rock loosened by the cutting tools fell directly into them, and the remainder was picked up from the bottom of the cut by them. The buckets were shaped to dump from their inner ends when they were in the highest position, the material falling through a hopper directly on the conveyor belt. As considerable dust was formed at the face when the machine was in operation, a fine spray of water was directed continuously against the face.

The conveyor belt was geared to the same shaft to which the shaft carrying the disk was geared, so it started and stopped with that shaft. The belt delivered to the boot of a bucket elevator at the rear end of the machine. This elevator raised the material and dumped it into a long narrow storage hopper suspended from the top of the cylinder. Enough clearance was made between the bottom of this hopper and a working platform in the cylinder so small cars could be run under the hopper and filled, four independently-operated gates permitting four cars to be filled simultaneously. Arrangements were made to carry cars to the surface by a freight elevator in the shaft from which the tunnel was driven.

The machine was arranged to make an advance of 2 ft. before it had to be moved forward. The shaft carrying the disk on which the planer tools were mounted was automatically pushed ahead by four positive-feed screws which bore through rollers against the rear face of the disk. These screws were geared to the 4-ft. shaft, so their rate of feed was controlled by the speed of the latter. Split nuts engaged the screws directly and could be released at will when the 4-ft. shaft was to be withdrawn into the cylinder. In order to provide for the travel of the shaft the various gears on the latter were made a little more than 2 ft. wide.

The machine rested on two pairs of high-power pneumatic jacks while in operation, one pair near the front and the other near the rear, both pairs being on the center line of the bottom of the tunnel. Eight pneumatic jacks, in two sets of four each were placed radially, to keep the machine in alignment while it is in motion. One set of jacks was placed toward the front end and the other toward the rear end of the machine, the four jacks of each set being placed one at each of the four 45 deg. points. The shafts of these jacks were all controlled independently so the course of the machine could be altered readily by manipulating them.

Two tandem-compound high-power pneumatic jacks were used to push the machine ahead. One of these jacks was placed along each side of the cylinder on the horizontal diameter of the cross-section of the latter, and toward the front end of the machine. The shafts of both jacks extended to the rear of the machine where they bore against a heavy built-up steel ring that is carried loosely at the end of the cylinder. This ring could be brought to bear against the sides of the machine with sufficient force to furnish a blocking base for the heavy moving jacks.

The motors driving the machine were operated from a switchboard at one side of the rear of the conveyor belt near the rear end of the machine. The various pneumatic jacks were operated by valves grouped together on the opposite side of the end of the conveyor belt. The operation of the machine could thus be controlled entirely by two men.

After the machine had been set up in the shop for trial runs, it was partially dismantled and shipped to the site, where it was re-erected in a chamber that had been built along the line of the tunnel adjacent to the bottom of the shaft. This erection was handled with less difficulty than might be imagined, although it had to be carried on in very congested quarters. The interior of the cylinder of the machine was almost completely filled with gears, jacks, shafts and so forth, a narrow man-way along each side of the revolving 4-ft. shaft being the only space not occupied.

The machine was arranged to cut at the rate of 1 in. a minute, but the rate of cutting could be changed quickly if materials of varying density were encountered. With ordinary tunneling methods the shale is of such nature that it would all have to be loosened by blasting before it could be removed, which would result in a large amount of breakage outside the lines of the tunnel as prescribed by the plans. This space would have to be filled with concrete, without pay, and it was considered that the saving of this extra concrete that could be made in the tunnel through the use of the machine would more than defray the cost of the latter.

A complete and exhaustive trial of the machine in the tunnel demonstrated that progress satisfactory to the engineers in charge of the work could not be made with it, so it was abandoned and removed, in order that the tunnel could be driven by ordinary methods. This journal has not been authoritatively informed to what cause the failure of the machine is to be attributed, but local reports indicate an inability to mesh simultaneously the sleeve nuts on the four positive-feed screws which bore through rollers against the face of the disk carrying the cutting tools, with the result that this disk could not be maintained normal to the axis of the tunnel.

The Para Harbor Improvements.

The Para harbor improvements, which have been undertaken under a concession from the Brazilian government furnish an instructive example of the valuable assistance private capital can render in the most important public works of a national nature, provided those furnishing it are assured of reasonable treatment. One of the notable commercial movements taking place today is the development of the great rubber district in the upper part of the Amazon valley and the improvement of transportation facilities so that the products of the east slopes of the Andes may be sent eastward instead of westward over the mountains and by a circuitous route to Europe. This development of the Amazon valley is a natural result of the growing importance of the Brazilian rubber trade, which has surpassed that in coffee of late, and has led to a better appreciation of the other resources of the valley. This has an area more than twice that of the Mississippi and discharges about three times as much water into the sea 65 miles to the east of Para, the port of this great district. The present port facilities of this city are admittedly inadequate for the existing business and would be a serious check on that of the future, so the government has granted a concession to parties with whom Dr. E. L. Corthell of New York is interested to build a modern port and collect port dues. In case the latter do not yield 6 per cent. on the investment, the government practically obligates itself to make up the deficiency. There will be a dredged entrance channel 1,000 ft. wide and deep enough for 10,000-ton vessels extending from deep water to the main quay, a distance of about 1.8 miles. The quay will have a rubble foundation and concrete superstructure, and will be equipped with fixed and movable electric cranes, warehouses, coal-handling plant, railway tracks and all other facilities needed to handle the business in the most economical and speedy manner. The construction will be carried out by S. Pearson & Son of London and Messrs. Schneider of Paris, and it is expected that the first section will be completed and put into service about 1912.

Book Notes.

The excellent collection of "Mechanics Problems for Engineering Students," prepared by Prof. Frank B. Sanborn, has been revised and enlarged. The book contains a great variety of problems drawn from regular engineering work to illustrate the principles of work, force and motion in a more interesting way than by the usual abstract exercises. It is a book equally useful to the teacher and to the ambitious student. (New York, John Wiley & Sons, $1.50).

The sixteenth annual edition of "Hendricks' Commercial Register" contains the names and addresses of over 350,000 parties covering the building, engineering, mechanical, railway, electrical, mining and metallurgical industries, classified under more than 31,000 headings. The publishers make no charge for fully classifying any firm's business, and the work is done solely with a view to answering completely all reasonable questions with which a reader turns to such a volume. Special attention has been paid to classifying the names so that the lists are equally useful to the purchasing agent or the catalogue distributor. For example, all parties having a machine shop or foundry are classified under the head of "Machinists and Founders" for the use of those desiring a mailing list of these trades, and each party is classified under heads covering every variety of its products, so that the names are available for the use of a purchasing agent. The book is the result of evolution from a list of the building trades which had only 1,648 classifications. From this small beginning in 1891 it has steadily grown in scope, size and accuracy, until it is recognized to-day as one of the best trade lists published. (New York, S. E. Hendricks Co., $10.00).

A new edition, the fifth, of Mr. Austin T. Byrne's "Treatise on Highway Construction" has been brought out, with about 120 pages of additional information. It has the same merits and defects as previous editions. Some of the information is practically obsolete, such as that relating to cement and concrete, and there are many sentences and paragraphs which are certainly not in harmony with the opinions held by some experienced paving specialists. On the other hand some of the chapters are particularly comprehensive and reliable. This inequality in the character of the contents can hardly be avoided, however, in a new edition of a book on a branch of engineering changing so rapidly as that under consideration. The great strides made during the last five years in the chemical technology in asphaltic cements, the progress in the construction of broken stone roads, the development of treated wood blocks and the improvements in asphalt blocks only recently undertaken, have rendered paving an interesting subject of study to those fortunate enough to become acquainted with what is taking place. As a result of this progress there is particular need of thoroughly revising books relating to paving work; Mr. Byrne would have done well, therefore, to have thrown away much more of the obsolete material in his book and to have condensed other parts. The book would have lost nothing of its encyclopædic character and gained in reliability; there is so much valuable information in the book, arranged so well for quick reference, that the next revision ought to be conducted thoroughly, so that the merits of the large amount of valuable matter are not overshadowed by the out-of-date or erroneous portions. (New York, John Wiley & Sons, $5.00).

Prof. Geo. C. Shaad, of the Massachuetts Institute of Technology, has written a good general manual of the engineering features of power stations and transmission. His purpose has not been to furnish a complete treatise, but merely to provide a general discussion which is accurate and at the same time not so technical that none but a graduate of an engineering college can read the book to advantage. The volume, which bears the title "Power Stations and Power Transmission," opens with a discussion of the location of the stations and the selection of the system of generating and transmitting the power. The general design of steam and hydraulic plants is then briefly outlined, after which the electrical equipment is explained. This section is followed by one on station buildings, records and office management. The whole first part is thus a well-balanced description of what may termed the generating end of the power plant. The second part is devoted to power transmission, and will be found particularly useful by those engineers who wish to obtain a general knowledge of the methods of designing this portion of a general power development undertaking. The author takes up in turn the methods of calculating the size of conductors, the various losses in transmission and the construction of the various parts of the line. This section of the book has been well prepared and may be profitably read in particular by those who have to take up for the first time such work. (Chicago, American School of Correspondence, $1.00.)

The young man who goes from a preparatory to an engineering school frequently finds the transition a disastrous one, largely because he has not been taught to make independent use of what he has learned. Hence there is a growing appreciation of the fact that the transition should be accompanied by training in the application of the knowledge gained in the preparatory school, in order to make the student realize that he has acquired an increased mental power, to review the work of the preparatory school in an interesting manner, and to give an outlook over the work of the engineering college. As a rule the preparatory work is least satisfactorily done in mathematics, and in order to remedy this defect, Prof. P. A. Lambert, of Lehigh University, has written a little book on "Computation and Mensuration," as a review of algebra, geometry and trigonometry and an introduction to their applications. The book assumes that the student has free access to his text-books on the branches mentioned and no attempt is made to prove formulas derived in such text-books. The book is an excellent introduction to a college mathematical course, particularly as it gives information concerning approximate and graphical methods of computations which are not ordinarily taught in preparatory schools. (New York, The Macmillan Co., 80 cents.)

Although the development of grinding and lapping in recent years has been one of the most interesting features of machine shop practice, very little has as yet been published concerning this and there is no general handbook on such work. Mr. Joseph V. Woodworth has accordingly rendered a distinct service in writing his manual bearing the title of "Grinding and Lapping." The book is in five sections. The first takes up the conditions, rules, methods, processes and attachments for accurate grinding and the use and préparation of abrasives. The second section is on laps and lapping; it discusses the construction and use of tools and processes for finishing gauges, tools, dies and machine parts to accurate dimensions. The third section is on the use and operation of grinding fixtures and jigs, for finishing repetition articles of metal, small hardened and tempered steel parts and special work. The fourth section is on hardening and tempering interchangeable tool-steel parts of delicate structure, which require to be ground and lapped afterwards. The fifth section is a table of the percentage of carbon that crucible steel parts of tools should contain, temper colors to which they should be drawn and degrees of heat for giving them proper tempers. In many respects the book is one of the most interesting contributions to our American works on machine shop practice, and the fact that almost all of it describes methods followed by the author or designed by him adds to the value of the text. Throughout the book there are references to experience with various methods of grinding and lapping which are decidedly instructive. (New York, Hill Publishing Co., $2.00.)

Letters to the Editor.

COST OF HAULING FARM PRODUCTS TO MARKET.

SIR: In the first article in your issue of Sept. 28, you mention me by name as having criticised some statistics published by the U. S. Department of Agriculture concerning the cost of hauling farm products to market, which reminded me of another investigation I partially completed some months ago and laid aside for lack of time; but as it is not likely to be completed soon, I will present a summary of it here, as it bears upon the matter to which you referred.

The Road Inquiry Office of the United States Department of Agriculture, under date of April 4, 1896, published in Circular 19, the data received from 1,061 counties. The conclusion is that in 1895 it cost the farmers $662,000,000 (70 per cent. of $946,314,665.54) to haul the crops of that year from the farm to the market.

Under date of Feb. 28, 1907, the same Department in Bulletin No. 19 of the Bureau of Statistics, publishes the data on Cost of Hauling Crops from farms to Shipping Points received from 1,894 counties. The conclusion of the later, and more elaborate, investigation is that in 1905 the cost of hauling twelve leading farm crops was $84,684,000. Of course, these twelves crops are not all that was hauled to market; but they must constitute the major part of the farm products. One of the points upon which I have been waiting for additional information is the magnitude of the other crops, but so far I have been unable to get any light.

On the face of the returns, the cost of hauling crops from the farm to the shipping point in 1895 was almost eight times as much as in 1905; but statistics of the same Department show that the weight of the seven leading crops in 1905 was a trifle more than double that of 1895. Therefore we may fairly conclude that the cost of hauling the crops to market as given by the first circular is practically sixteen times as great as that stated in the later Bulletin.

There are four serious errors in the last investigation, each of which tends to make the conclusion too large.

1. The question asked for the "usual medium load for each of the principal products." The mean between the heaviest and the lightest load may differ greatly from the average of the loads actually hauled, since the bulk of the products are hauled when the roads are in better than average condition. According to the U. S. Bulletin the average load of corn in Illinois is 2,754 lb., while the Illinois Agricultural Station in Bulletin No. 50 published the statistics for marketing 311,845 bush. of corn, which shows that the average of loads actually hauled was 62 bush. If this was all shelled corn, the average load was 3,468 lb.; and if it was all unshelled corn, the average load was 4,400 lb. As doubtless the most of the corn was shelled, the average load was probably only a little greater than 3,468 lb.; but even the 3,468 lb. is 21 per cent. greater than that stated in the U. S. Bulletin.

2. The cost to the farmer of a team and driver is assumed to be "the price for which teams are hired for any purpose." Of course there is a great difference between the actual cost to the farmer of a man and team hauling crops to mar-

ket, and the price paid for driver and team to work, say, at railroad grading, or hauling a highway bridge to its site. Judged by the estimates of 316 farmers in 76 counties in Illinois, reported in the Illinois Bulletin mentioned above, the price assumed in the U. S. Department Bulletin is about 24 per cent. too large.

3. The question asked for "the greatest distance of haul by any considerable number of farmers," and the assumption was made that the answer to this question represented the radius of the tributary area. This procedure overlooked the fact that for many places there is one direction from which produce is hauled much farther than from other points of the compass; in other words, this method measures to the end of the pan-handle to find the area of the pan. The U. S. Bulletin states that the average length of haul for corn in Illinois is 5.7 miles, while by the Illinois Bulletin referred to above the average length of haul in marketing over 300,000 bush. of corn as reported by 316 farmers in 76 counties was 3.2 miles. Apparently then for this reason the results in the second U. S. Bulletin are about 44 per cent. too large.

4. The amount of wheat hauled by wagons from the farm to the mill is not included in the statistical returns, but this item is estimated and then added. This esimated correction is distinctly equivalent to saying that a trifle more than one-third of all the wheat not used for seed is hauled in wagons to the local mill. The amount thus added is almost one-sixth of the total weight of all other crops, and hence any considerable error in this item will materially affect the final result. I have looked for statistics by which to check this estimate, but have found nothing of value. However, in view of the great quantity of wheat that is exported unground and also of the large amounts that are ground at Minneapolis and other milling centers, it can not be that more than one-third of the wheat not used for seed is wagoned to the local mill.

If we correct the results of the second U. S. Bulletin as stated in paragraphs 1, 2 and 3 above, the actual cost will be about 44 per cent. of that stated, not counting the error referred to in paragraph 4. The cost of hauling crops from the farm to the market stated in the first U. S. Bulletin is then about thirty-six times the value given in the last bulletin, provided we assume that the latter value includes substantially all the farm products. If we should allow 25 per cent. for the omitted crops, and should neglect the error in the opposite direction referred to in paragraph 4, the results in the first U. S. Circular would still be twenty-seven times too great.

Of course the above method of "correcting" statistics is not mathematically exact, but it is certainly sufficient to show the absurdity of the first circular referred to. Unfortunately that investigation has been largely used in discussions of wagon-road economics, and the only object of this communication is to show its utter unreliability. The hope is that with these very erroneous statistics out of the way, a more rational consideration of good-road problems may prevail.

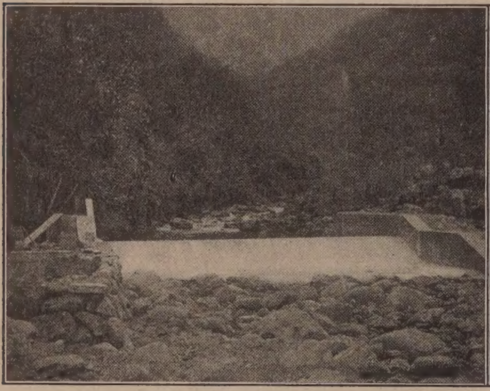
IRA O. BAKER.

CHAMPAIGN, ILL., Oct. 4. 1907.

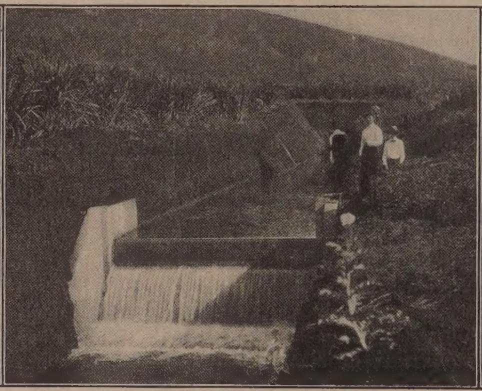
The New Waihee Canal.

SIR: The completion of the new Waihee Canal on Maui adds another important irrigation work to the sugar industry of the Island of Maui and the Territory of Hawaii. The new ditch provides first, for the irrigation of the several thousand acres of new land of suitable quality for the successful cultivation of sugar cane, heretofore arid and utilized only as pasture land; second, for a permanent supply of water for the cane lands already under cultivation; and third, for conveying the freshet water of the Waihee Valley to storage reservoirs where it is conserved for irrigation purposes, thus augmenting the normal water supply derived from the Waihee, Waiehu, Iao and Waikapu streams.

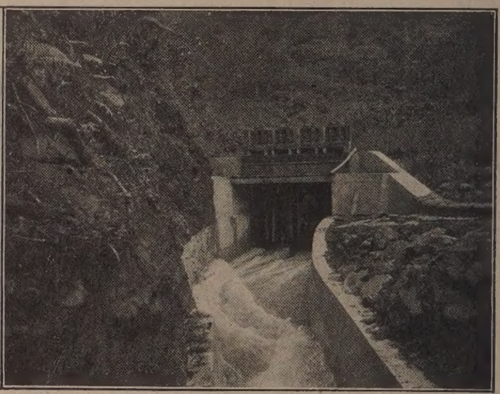
The division dam and head-works of the canal are located just below the famous Aliele Falls in the Waihee Valley, at an elevation of 649.5 ft. above sea level and 2½ miles up the valley. The cement-lined ditch from the dam and head-gates is located along the south bank of the Waihee Stream on a bench wall above the flood line, passing almost immediately through Tunnel O, 320 ft. in length. The conduit extends some 2,000 ft. to the portal of the next tunnel and thence continues, still tunneling the mountain spurs and high ridges forming the foot hills of the high mountain range of West Maui, spanning the deep gulches by flumes and skirting along and through the cane fields by open ditches to the north bank of the Iao Valley near the town of Wailuku, for a distance of approximately six miles. The original contour survey showed nine miles, making a saving of three miles of conduit by the present line as constructed. It next crosses the valley by pipe line and continues by easy curves and long tangents through the cane fields of the Wailuku Sugar Co. to the Waikapu Valley in open ditch, thence by tunnels and cutting under the Waikapu Stream, again following the grade contour through the new lands of Waikapu and Puuhele Plains, where many new reservoirs are located.



Waihee Dam.



Weir on Main Canal.



Headgates.

The conduit consists of 22 tunnels, having a total length of 16,539 ft.; 39 flumes aggregating 2,764 ft.; 35,549 ft. of open ditch, and 1,253 ft. of pipe, making a total of 56,105 ft. or 10.62 miles.

Of the 22 tunnels, the longest is 2,246 ft., located in the Waihee Valley, and the shortest is in the Waiehu Valley, making the average length of all the tunnels approximately 750 ft. The dimensions of the tunnels are as follows: Bottom width, 5.5 ft.; center height, 6.5 ft.; side height, 4 ft., with width of 6.5 ft. at the spring of the arch, making a cross section similar in outline to a horseshoe.

All of the tunnels are cut to a true line and uniform grade of 0.25 per station of 100 ft. or 13.20 ft. per mile, except the first tunnel, which is of a smaller cross-section and has a grade of 3 ft. per 100 ft. and is cement lined and arched with concrete. About 40 per cent. of the tunnels are lined with concrete and cement plaster to prevent loss of water by seepage and caving where the rock is soft and porous.

The cutting of tunnels was all done by Japanese labor, the contract prices ranging from 85 cents to $5 per foot, according to the material cut, the location and the length of the tunnel. Eighteen months were required in cutting the longest tunnel, 2,446 ft. in length. Very hard rock was found. Compressed air and percussion drills were used in four tunnels. The formation in the long tunnels was principally of lava rock of alternate strata of aa and pahoehoe, with a slight dip to the sea.

The flumes, 39 in number, vary in size according to grades and capacity required, 3 x 4, 4 x 4, 4 x 6 and 4 x 7 ft. The waterways are constructed of redwood lumber with trestle and floor system of northwest lumber.

The open ditch varies in cross-section and grade to comply with the conditions of soil and capacity, being designed to carry the maximum capacity without cement lining. Approximately 20 per cent. of the open ditch has been cement lined on bottom and sides.

The steel pipe line crossing the famous Iao Valley is 1,253 ft. in length and 3 ft. inside diameter, conveying the water under the bed of the Iao Stream and delivering it into a cement basin 13 ft. in diameter, thence through a tunnel 439 ft. in length to a permanent weir, where the total flow of the canal can be accurately measured at all times.

The capacity of the conduit is 45,000,000 gal. in 24 hours, or 69.81 cu. ft. per second, after making liberal allowance for seepage and evaporation.

Construction on the canal was commenced in March, 1905, and completed in June, 1907. The construction of the canal was the result of an exchange of land and water rights on the part of the Wailuku Sugar Co. and the Hawaiian Commercial & Sugar Co. in settlement of their respective rights to the waters of the Iao Valley, which had been in litigation for years past. The cost of the canal in round numbers is $160,000.

The writer has been chief engineer of the works from start to finish, locating and designing and constructing the works of the Wailuku Sugar Co., of Wailuku, Maui, Brewer & Co., of Honolulu, Agents. Mr. George B. Sturgeon, now of Oakland, Cal., was assistant engineer, with location and the principal portion of the construction work.

JAS. T. TAYLOR,
Member American Society C. E., Consulting
Hydraulic Engineer.